THE POLYTECHNIC SERIES.

FORTY LESSONS
IN
ENGINEERING WORKSHOP PRACTICE

AS TAUGHT TO THE BOYS OF THE POLYTECHNIC TECHNICAL DAY SCHOOL.

E25/83

BY
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REVISED BY
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LA BELLE
SAUVAGE

PREFACE.

THIS course of Lessons has been prepared to assist Boys and Students in Technical Schools and Classes who are taking one year's course in Engineering Workshop Practice, and also to meet the demand for a suitable work of the kind for beginners.

The course is the same as that observed in the Workshop Practice at the Polytechnic Institute, and the Lessons have been arranged in a progressive manner with the able assistance of my colleague Mr. E. G. Davey; the method adopted being, as far as practicable, to make useful tools while gaining instruction, so that time and material may be profitably employed. This system, I am pleased to say, has already produced flattering results.

I take this opportunity of thanking Mr. J. Rogers, M.A.S.E., Instructor in Engineering Workshop Practice at the Polytechnic Institute, for his careful revision and his valuable suggestions.

CHARLES F. MITCHELL,
Senior Teacher of the Technical Division, Polytechnic Day School, London.

December, 1889.

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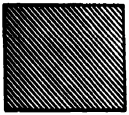
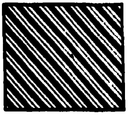
INTRODUCTION.

BEFORE going to the Workshop the Student should prepare full-sized working drawings of the tool he desires to make from the figured illustrations in the book, which he will notice have all dimensions placed vertically for convenience of reading same, and all sections hatched to indicate the materials. The following are the sections used throughout this work :—


CAST IRON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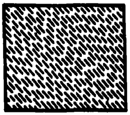
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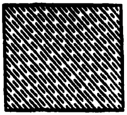
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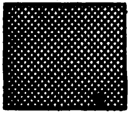
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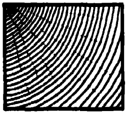
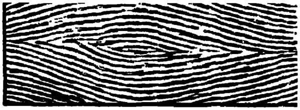

WOOD.
CROSS SECTION


WOOD.
LONGITUDINAL SECTION.

It is advisable to take off and make a list of all quantities from the drawings, and these for convenience may be added to the same.

FORTY LESSONS
IN
ENGINEERING WORKSHOP PRACTICE.

LESSON I.

THE student should be taught the names and uses of the following tools and other articles, viz. :—

Hand and bench vices, vice-clamps, bar-blocks, and clamping-plates.
Grindstone, grit-stone, oil-stone, and slips.
Hand and rivetting hammers.
Chipping, cross-cut, diamond-point, and round-nose chisels.
Centre, dot, round and sett punches, tommies and drifts.
Back, tee, and centreing squares.
Bevils.
Spirit-level, plumb-bob and line.
Inside and outside callipers and dividers.
Straight-edges, rules, and surface-plates.
Gauges for boring, turning, screw-cutting, nuts, centres, and drills.
Scribing-block, steel and brass scribers.
Stocks and dies, screw-plates, taps for bolt, gas and brass threads.

Chasers or screwing tools.

Rimers and broaches; half-round or D, rose and wood-packed bits.

Files—taper, flat, half-round, round, square, triangular, hand or safe edge, saw, slotting and other files of special shape, in bastard, second, smooth, dead-smooth and float-cut; and rasps.

File-brush or card.

Drills—flat, pin, twist, keyway and stock.

Countersinks, flat and rose.

Frame and back saws.

Hand-turning tools—gravers, parting, side, scraping, boring, screwing and milling tools.

Slide-rest turning tools—roughing, boring, knife, side, parting tools, spring and scrapers, cutters and holders, vee and square thread-screwing tools.

Lathe with hand-rest, driving and various other chucks.

Lathe with slide-rest, mandrel, back gear, division-plate, face-plate, angle-plate, cone-plate, and various chucks.

Lathe with saddle and leading-screw, change-wheels, studs and quadrant-plate, self-acting for feed and surfacing, cross-slide and clamping-nut.

Drilling-machines (hand and power), hand and ratchet braces.

Fiddle, bow or breast-drill stock.

Emery-wheels, cloth and paper, flour-emery, crocus, Tripoli and other polishing powders, laps, buffs, and polishing sticks.

Forge (fitted with bellows or fan), anvil, tongs, coupling-rings, top and bottom shaft and rod tools, swages, fullers, flatters, bolsters, mandrels, punches, bolt tools, hot and cold chisels, water-trough, shovel, poker, raker, lime, sand, and breeze or coke-boxes.

Gas and mouth blowpipes, copper bit, soldering-iron, hard and soft solders, borax, spirits of salts, oil, resin, spelter, and other materials and tools for hard and soft soldering.

LESSON II.

GRINDING.

IN grinding tools for metal working, the grindstone should revolve in a direction towards the workman, in order to avoid the formation of feather edges; but for lads and inexperienced workers it is safer when revolving from the workman. It should be wetted with a little clean cold water while the grinding is proceeding, to keep the tool cool and prevent its temper from being lowered or drawn. The stone should not be allowed to run in water, as it is softened thereby and does not cut so well.

It is advisable to move the tool while grinding, when practicable, from left to right, across the face of the stone, to prevent the stone from wearing in grooves and losing its even surface.

Metal-working tools should be held firmly down upon a fixed rest while grinding.

LESSON III.

ANNEALING.

ANNEALING is a softening process for allowing the particles of which a metal is composed, and which have been strained, to return to their normal or original position.

Steel may be annealed by heating to a blood-red heat and allowing it to cool slowly, preferably in a covered box filled with unslaked powdered lime, which retains the heat a long time.

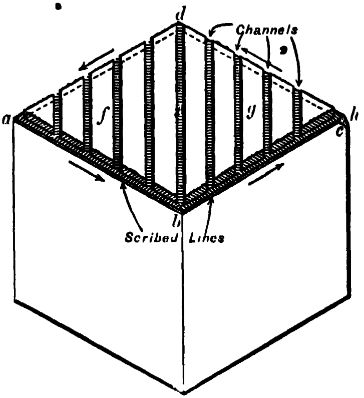
Iron that has been rendered brittle by hammering or drawing may be annealed by heating to a blood-red and allowing it to cool slowly.

Brass, copper, and gun-metal may be annealed by heating to a black-red and plunging into cold water. In the process of drawing brass and copper into wire through a draw-plate, it becomes hard and brittle, and breaks off; but if annealed, it becomes softened and can be drawn more easily and into finer wire.

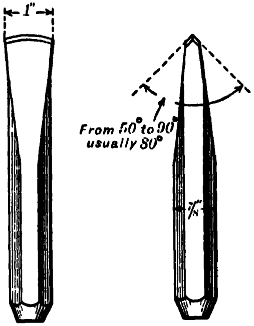
LESSON IV.

CHIPPING.

TO chip the upper face of the block shown in Fig. 1, line out as shown with a brass scribed line, and fasten the block in a vice with the lines *a*, *b*, *c*, *d* horizontal and about 1 inch above the jaws. Select a cross-cut chisel about ¼ inch wide, and see there is no grease upon the head of the chisel or hammer-face. Hold the chisel firmly but not tightly in the left hand, and place its cutting edge upon the work, inclining the chisel about 35° or 40°, and drive it forward by a series of light blows upon its head with a hand hammer. Two or three blows will suffice to show whether the angle at which the chisel is held and the force applied are correct. If the chisel is penetrating the work too deeply, lower the head of the chisel and use less force; but if not deep enough, raise the head of the chisel and use more force. A heavy cut will cause the chisel to penetrate more deeply when held at a given angle than a light one. Experience is the best guide.



Elevation.
Fig. I.



Elevations.
Fig. 2. Fig. 3

Commence to cut the metal at *a* down to the line, leaving the line well showing, so that it can be properly levelled with a file afterwards; and chip towards *b*. Then to *d*, and then from *b* to *c*, *c* to *d*, and *d* to *a*. When all these points are reduced to one level, the middle portions, *f* and *g*, may be removed by cutting channels as shown, taking care to leave the centre portion at *e* a little higher, and the width of metal between the channels rather less than the hand chisel used to remove them (usually $\frac{3}{4}$ to 1 inch). In chipping surfaces, especially those of cast metal, be careful to work from the corners towards the centre of edges of the block, so as to avoid breaking out the corners as shown at *h*, Fig. 1. A piece of cotton waste saturated with oil should be at hand, into which the point of the chisel should be dipped occasionally to keep its cutting edge cool, and form a lubricant when cutting.

Care should be taken that the cutting edge is slightly wider than the body of the chisel, ground to an angle of about 80° slightly rounding, as shown in Figs. 2 and 3, and tempered to a brown yellow colour.

LESSON V.

FILING.

WORK, rough from the forge or foundry, is sometimes prepared for filing, by removing the sand, skin or scale with an old file, or by chipping, grinding, or pickling, so as to avoid damage to the file.

In filing, the jaws of the vice should be level with the elbow, or from 40 to 44 inches high; heavy work, which requires more force used upon it than light, being placed lower in the vice. The feet should stand firmly on the ground, and be separated from 10 to 20 inches, according to the work to be operated upon, and the knees not kept rigid.

For ordinary work, grasp the file in the right hand, thumb resting horizontally upon the handle, and forefinger pointing along the file, the head or point being grasped with the left hand, the ball of the thumb resting on the upper side, and the four fingers down over the end holding the file.

The file should be held firmly, and pressed on the work with both hands in the forward, and lifted off in the backward stroke, to avoid damage to the file.

Any variation from the straight line, due to the swinging motion of the arms, must be compensated for by raising or lowering the wrists and elbows.

When the work has been filed all over in one direction, it should be filed at right angles, or diagonally, to the first cut, as shown in Fig. 4, or a slight motion from left to right given to the file during each cut, so that the cut of the file may cross frequently, and prevent the formation of hollows.

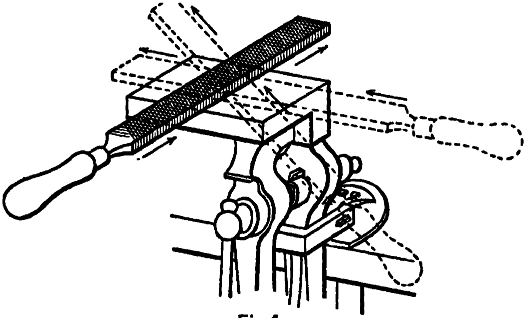


Fig 4.

The work should be frequently tried during progress in various directions, with a straight-edge; the edge of which may have a thin coat of "reddle" (red lead and oil) smeared upon it; serving to mark the high places upon the work, which should be filed down carefully, until the whole surface is of the desired flatness.

LESSON VI.

CENTREING WITH SCRIBING BLOCK.

TAKE a piece of steel ¾ inch diameter, and 3½ inches long, and anneal it as described in Lesson III.

File each end flat, and square with the length, testing with a back-square; and rub the ends with a piece of chalk, and place in one of the vees of a vee block, standing on a plane surface, as shown in Fig. 5. Take a scribing block and set the pointer a little above the supposed centre of the steel. Hold the steel into the vee groove with the left hand, and with the right hand move the point of the scriber across the chalked end of the steel, scribing a horizontal line. Turn the steel in the groove about a quarter circle, until the previous line becomes vertical, and scribe another horizontal line; give the steel another quarter turn and scribe a third,

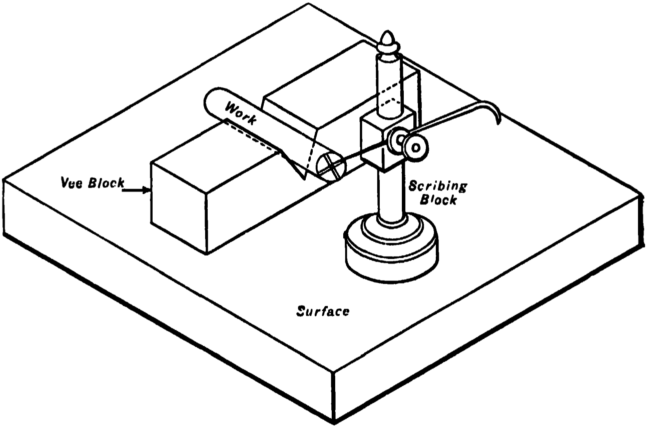


Fig. 5.

and likewise a fourth line; thus marking upon the end four lines. The central space enclosed by these lines indicates the centre required, and should be marked lightly with a dot-punch.

Repeat the scribing at the opposite end, and dot punch.

Place the steel between the lathe centres, and spin round with the left hand, on the holes made by the dot-punch. If centred correctly, it will run true and concentric, but if it runs eccentric, or out of truth, take a piece of chalk in the right hand, and resting it upon the hand-rest, advance the chalk gradually towards the end of the steel, until the portion of the steel farthest from the centre is marked with the chalk. It should then be removed from the lathe, and fixed in a vice, and the dot centre drawn with a centre-punch towards the chalk mark; repeating the process until the steel runs true at the ends. If the ends run true, and the centre out of truth, the steel is bent, and should be spun round and chalked as before described. Then place the steel, with the chalk mark uppermost, over the hollow of a bench-block, and give it a smart blow with a hand hammer upon the chalk mark, judging the force necessary to be used by the size of the steel, and the amount it is out of truth. The blow will help to straighten the steel, which should be taken to the lathe, and again tested, repeating the process until it runs true throughout its length. The centres should now be made larger with a centre-punch, and a carrier fixed on one end, and placed in the lathe, and the opposite end should be faced off square with a side or knife tool. Remove the carrier to the squared end, and square off the remaining end to the finished length. Then replace the running centre with a drill-chuck, containing a $\frac{3}{32}$ inch diameter drill for ordinary work, and with the aid of the back-centre and a little oil, drill up the steel at each end about ¼ inch deep. And countersink each slightly with a countersink, or a square centre, made the same angle as the lathe centres, usually 60° for ordinary work. The steel is now ready for turning.

Work is drilled up to preserve its centre, in case it should require turning or truing at a later period, and to protect the points of the lathe centres from damage.

LESSON VII.

HAND-TURNING TOOLS.

FIGS. 6 to 20 illustrate the hand tools ordinarily used for turning steel, wrought-iron, and cast-iron. These are usually made from square tool steel of from ¼ to ⅜ inch side, forged, filed, or ground to shape and hardened and tempered to a dark straw colour, the opposite end being pointed for driving into a wooden handle.

Figs. 6 and 7 illustrate the graver, a tool generally used for roughing out work. The point is sometimes ground off as at A to increase the strength of the cutting edge.

Figs. 8 and 9.—The round-nose tool for roughing out and forming hollows in the work.

Figs. 10 and 11.—The side-tool, used for facing collars, shoulders, and ends. Made from a worn triangular file.

Figs. 12 and 13.—The parting-tool, used for dividing work while revolving in the lathe.

Figs. 14 and 15.—The outside screwing-tool, chaser, or comb-screw tool, used for making external screw-threads.

Figs. 16 and 17.—The inside screwing-tool, used for making internal screw-threads.

These screwing tools are made by pressing a steel blank, previously forged, annealed, and filed to shape, against a "hob" or master-tap whilst it revolves in the lathe, lubricating both with oil.

Fig.6.

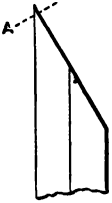


Fig.7.

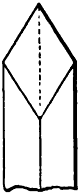


Fig.8.

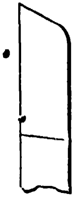


Fig.9.

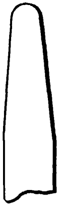


Fig.10.

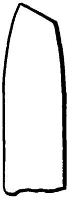


Fig.11.

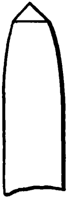


Fig.12.

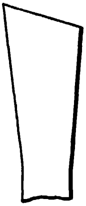


Fig.13.

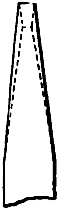


Fig.14.

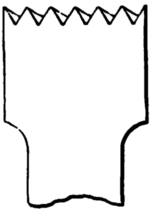


Fig.15.

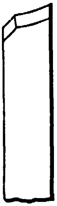


Fig.16.

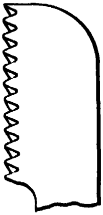


Fig.17.

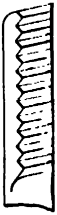


Fig.18.

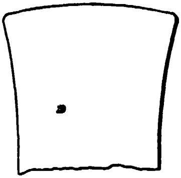


Fig.19.

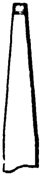
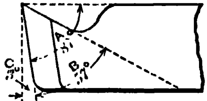


Fig.20.



A. Angle for Cast Iron and Brass.
B. " " Wrought " " Steel.
C. " " Clearance. "

The tempered hob gradually cuts a series of parallel grooves in the soft blank, the exact counterpart of the threads upon the hob. When a full thread is attained, the screwing-tool should be "backed" for clearance, and tempered, and may then be used to cut screws of a similar pitch to the thread upon the hob.

Inside screwing-tools are first grooved with the hob, and bent to shape before tempering.

Chasers of coarse pitch should be roughed out approximately to the pitch of the screw with a triangular file to preserve as much as possible the threads upon the hob.

Figs. 18 and 19.—The scraper used for polishing cast iron and other metals while revolving in the lathe. It is usually made of a worn flat file, forged thin at the end and ground slightly rounding (shown exaggerated), and oilstoned to 90°.

It should be used resting upon a piece of leather, placed upon the hand-rest to prevent chattering, and so as to scrape a polish upon the work rather than cut one.

Fig. 20 is a diagram showing the cutting angles for wrought-iron and steel, cast-iron and brass, and the method of applying the same so as to leave the cutting-edge as strong as possible.

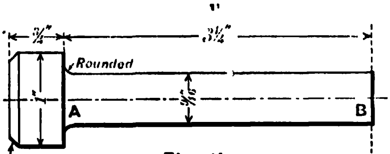
LESSON VIII.

TURNING.

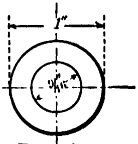
TAKE a piece of iron 1⅛ inch in diameter and 4 inches long, square the ends, centre, drill up and countersink as in Lesson VI. Turn to dimensions shown in Figs. 21 and 22. Place a carrier upon the head A, and adjust the work between the lathe centres, so as to move freely without end play, and with the driving tail of the carrier against the driver of the driving chuck. Adjust the hand-rest about ¼ inch below the level of the lathe centre, and about ⅛ inch away from the work.

Set the lathe in motion, and taking a graver, hold the handle in the right hand and grasp the middle of the length of the graver in the left hand.

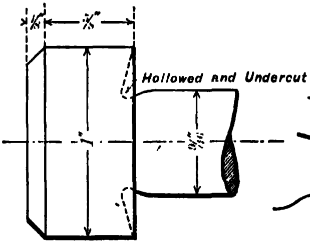
Place the graver on the hand-rest point downwards and to the right, as shown in Fig. 24, and advance it slowly about $\frac{1}{16}$ inch into the work; then give the



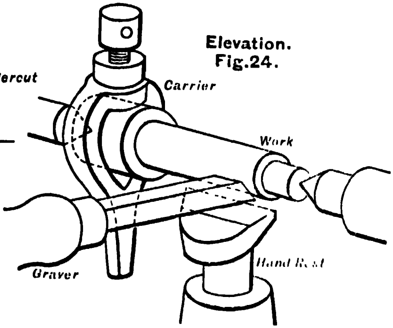
Elevation.
Fig. 21.



Elevation.
Fig. 22.



Elevation.
Fig. 23.



Elevation.
Fig. 24.

graver a twisting motion towards the left with the right and left hands until the point of the graver reaches the top. Then turn the point down as before, and commencing where the last twist left off make another; and so on along the work to the length desired. Should any lumps be met with on the work, not true, hold the graver firm on the rest and let them cut themselves level with the other portion of work against the graver, advancing the graver slowly into them each time they come round. Commence again at the point and take another cut along the work, by stages as before, lubricating the graver with a little soap and water. Be careful to avoid the formation of hollows, and to keep the point of the work at B smaller than the other portions, until nearly of the desired diameter. Then make it parallel throughout its length, by testing with the outside callipers, setting them so that they just "feel" the smaller portion, but not tightly. Then square up the head with the graver or side-tool, taking care to leave a slight round in the corner, as at A, Fig. 21, and not undercut and hollowed, as shown exaggerated in Fig. 23.

Put the carrier on the point B (Fig. 21), and turn the head to dimensions, and chamfer as shown in Fig. 21.

Run the lathe at a fast speed, oil the back centre and with a 6-inch dead-smooth hand-file, holding the handle in the right hand and the point of the file with the two first fingers and thumb of the left hand, press the file gently upon the work, pushing it forward with a slow stroke, taking care that the lathe revolves several times during its progress.

Avoid using the file much, as if the work has been well done two or three strokes will be quite sufficient.

Place the carrier upon the end A, and file the smaller diameter in a similar manner, testing with the outside callipers to see that it is kept parallel, and polish with a piece of emery-cloth stretched tightly on a flat stick and some oil.

LESSON IX.

FILING CYLINDRICAL WORK SQUARE.

TAKE a piece of steel that has been turned and place between the lathe-centres with a carrier upon the end.

Set the division-peg in No. 1 hole of the division-plate, and with a scriber or sharp tool bolted in the slide-rest, scribe a horizontal line along the steel.

Take out the division-peg, and supposing the division plate is divided into 100 parts, move the headstock round until the division-peg drops into the 25 hole; then scribe another horizontal line upon the steel. Move round the headstock to the 50 and 75 holes respectively and scribe lines, marking the steel as shown in Fig 25. Remove the steel from the lathe and place in a vice, and scribe upon each end a square (the 4 lines already scribed serving to indicate the corners), dot-punch the squares with fine dots, which will cut out when the work is completed.

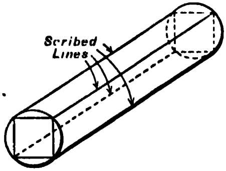


Fig.25.

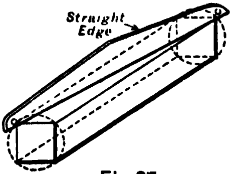


Fig.27.

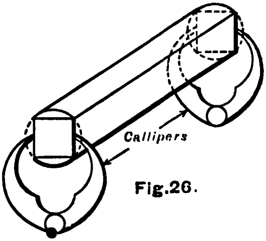


Fig.26.

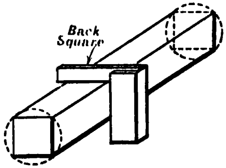


Fig.28.

Place the work in a vice and file away the metal down to the lines, at first with rough and then with smooth files, doing the opposite sides first. Test the work with the straight-edge and square, as in Figs. 27 and 28, and make the opposite sides parallel to one another, testing with the outside callipers, as shown in Fig. 26; and at right angles with the other sides, testing them with the back square, as in Fig. 28.

When all is corrected, finish by smoothing and polishing.

LESSON X.

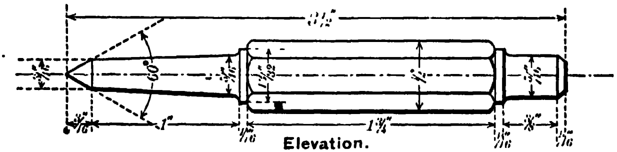
CENTRE-PUNCH.

TAKE a bar of $\frac{5}{8}$ inch diameter steel, and cut off a piece $3\frac{3}{4}$ inches long, by placing it flat on a bench block, and nicking it all round with a hammer and chisel $3\frac{3}{4}$ inches from one end. Place the nicked portion over a hollow in a bench-block, and by giving it a sharp blow with a hammer upon the nicking, it will break off.

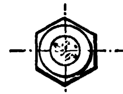
Anneal the piece as described in Lesson III., and square and centre the ends. This may be accomplished by trial or by using a pair of dividers, having one of its legs bent rounding, the ends of the steel being chalked, and four lines scribed upon each, as shown in Fig. 31.

To do this, set the point of the dividers a little out of the supposed centre, and using the rounded leg of the dividers as a guide, describe the four curved lines with the point, as shown in Fig. 31. The space enclosed by these lines will indicate the centre required; which should be lightly marked with a dot-punch, and taken to a lathe and tested, as described in Lesson VI. Be careful not to make the centre too large at first, and to keep the centre-punch upright in line with the centre of the steel.

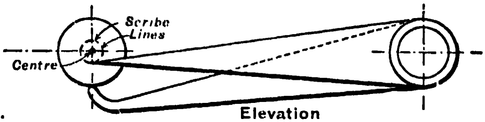
When centred correctly, place a carrier on one end and turn to dimensions shown in Fig. 29, and smooth and polish. Then set the punch to run true in a universal chuck, and turn off the centred ends, making the centre point to the same angle as the lathe centres. This in Whitworth lathes is 55°, usually 60°, and for heavy work 45°.



Elevation.
Fig. 29.



Elevation.
Fig. 30.



Elevation
Fig. 31.

The central portion may be left round, or scribed and made hexagonal, octagonal, or square, according to taste. When finished, the centre point should be hardened and tempered to a brown straw colour.

LESSON XI.

DRILLS.

THE varieties of drills most commonly used are shown from Fig. 32 to Fig. 45.

Figs. 32 and 33 are that form of drill used in the bow or fiddle drill stock; it is very useful for drilling small

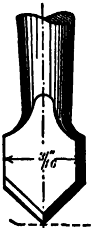


Fig.32.

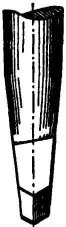


Fig.33.

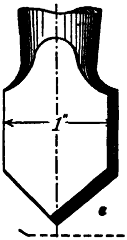


Fig.34.

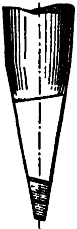


Fig.35.

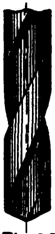


Fig.36.

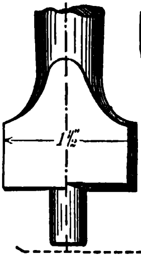


Fig.37.

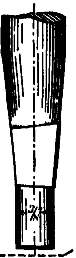


Fig.38.

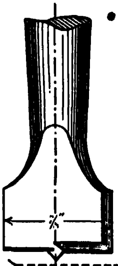


Fig.39.

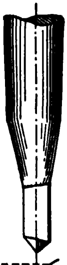


Fig.40.

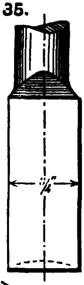


Fig.41.

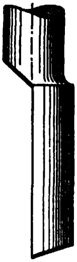


Fig.42.

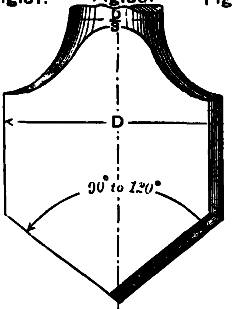


Fig.43.

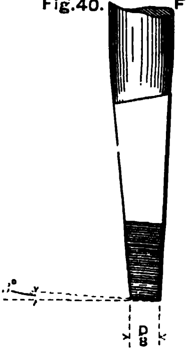


Fig.44.

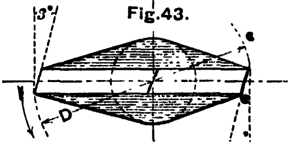


Fig.45.

holes, and holes in positions where a machine cannot be used.

Figs. 34 and 35 are the ordinary flat drill, used in the lathe, drilling machine, ratchet, and hand braces.

Fig. 36 is a "twist drill," used in the lathe or drilling machine.

Figs. 37 and 38 are the "pin drill," or "pin cutter," in using which a small hole is drilled first in the work to fit the pin, forming a guide for a larger hole; used in the drilling machine and ratchet brace; and useful for recessing holes to let the heads of bolts, etc., in flush with the surface.

Figs. 39 and 40 are the "keyway," or "flat drill," used in the lathe, drilling machine, and hand braces, for making the holes for keys and feather ways in shafts, and for recessing work, when a pin drill cannot be used.

Figs. 41 and 42 are the "half-round," or "D" bit, used in the lathe, the end of the hole being first trued with a boring tool, to form a true start for the bit which makes a round, straight, and parallel hole, and has the great advantage of not decreasing in size by grinding.

Figs. 43, 44, and 45 give the usual proportions of a flat drill. They should be turned to the correct angles, and parallel for some distance back as shown, so that they may be ground several times without decreasing their diameter. The cutting edges should be filed or ground, so as to be of equal length and inclination, otherwise one edge will do all the cutting; or the hole will be drilled elliptical. The parallel portion should be eased off or "backed" to a clearance angle of about 3°, as shown in Fig. 45, to prevent heating. The point having but little cutting action, has to be forced into the work; and should not be wider than experience and the material to be drilled determine. Flat drills should be tempered to a light straw colour, and twist drills to a dark yellow colour, and used with a lubricant of oil or soap and water for steel and wrought-iron, and without lubricant for cast-iron and brass, or if the cast-iron is very hard, a drill hardened "right out," and lubricated with turpentine is useful.

Twist drills should only be ground in specially prepared apparatus.

The usual speed of drilling steel is 12 feet per minute at circumference of drill; cast-iron, 18 feet; wrought-iron, 24 feet; and brass, 25 feet.

A useful gauge for the angles of drills is shown in Fig. 50, the divisions serving to adjust the length of the cutting edges.

LESSON XII.

DRILLING.

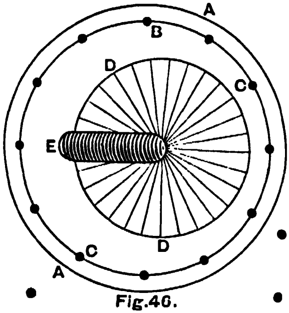


Fig. 46.

FOR drilling a hole, the centre should be marked lightly with a dot-punch, and taking a pair of dividers, set them to a little less than the half diameter of the finished hole A. Then scribe a circle B (Fig. 46) from the centre, and dot-punch the circle, with fine dots, C, so that the dots will cut out when the hole is drilled.

Make the centre larger with a centre-punch, and commence to drill. If the hole is running out from the centre of the circle, as shown at D (Fig. 46), take a round-nosed chisel and cut a groove from the edge to the centre as shown at E; this will draw the centre of the drill towards the groove and cause it to cut that way, and must be repeated until the drill runs central with the dot-punched circle.

This process is known as "drawing a hole," and must be accomplished before the drill has cut its full diameter into the work.

LESSON XIII.

FILING HEXAGONAL HEAD.

TAKE a blank similar to that turned and screwed in Lessons VIII. and XXVI., and divide the head into six equal parts with the division plate, and at each division scribe a horizontal line, as described in Lesson IX.

Remove the blank from the lathe, and join the lines as shown at 1, 2, 3, etc., Fig. 47, with a brass or steel scriber, scribing two hexagons upon the head, one at each end.

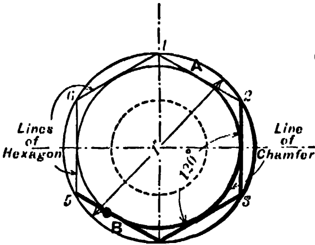
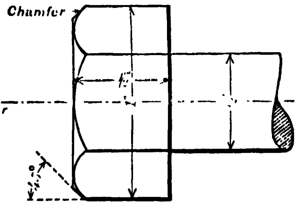


Fig. 47.



Elevations.

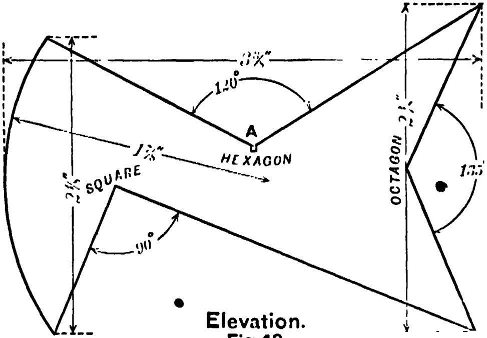
Fig 48.

Place the screw in a vice, between a pair of lead clamps, so as not to injure the screw-thread, and file away the metal to the hexagon scribed lines, taking care to make the faces square with the head. Do the opposite sides of the hexagon first, as A and B, and make them parallel, testing with a pair of callipers, and make the angles to fit the nut gauge correctly. When correct, file smooth and polish, and place the bolt in the lathe and chamfer the head, as shown in Fig 48.

LESSON XIV.

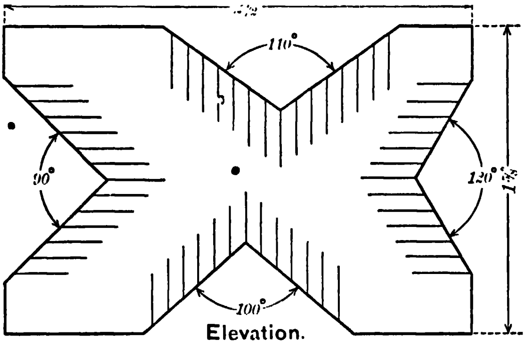
NUT AND DRILL GAUGE.

TAKE two pieces of sheet steel, one 3½ inches by 2½ inches, by 1/16 inch thick; and one 2⅝ inches by 1¾ inch, by 1/16 inch thick, and mark out carefully to shapes shown in Figs. 49 and 50 with a sharp scriber. With a hand chisel and hammer, cut out roughly to shape, and file up the edges and angles with rough files. Smooth and finish the angles, taking care to make them exact and correctly pointed; for which purpose a flat-back, half-round, dead-smooth file may be used, or the angle point cut in with a fine back saw, as shown at A, Fig. 49.



Elevation.
Fig.49.

Hold down the gauge on the clamp plate, as shown in Fig. 51, and smooth-file the sides; after which the file should be chalked, to prevent its teeth from penetrating the work too deeply, and the work draw-filed, by holding the file in the position shown in Fig. 51, and drawing the file forwards and backwards in a parallel manner upon the work, as indicated by the arrows. When very smooth and free from deep scratches on both sides, take a piece of No. 1 emery-cloth and wrap round the file, or polishing-stick, and use in a similar manner to draw-filing, finishing the polishing with finer emery-cloth. A little oil used with the emery-cloth while polishing gives a better and more durable polish.



Elevation.
Fig. 50.

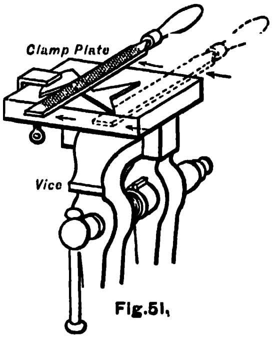


Fig. 51.

Draw-file the angles very carefully, and finish with one or two rubs with the finer emery-cloth.

Draw-filing should not be resorted to for accurate work; the smoothness of which should be accomplished by using files gradually finer in cut, and in one direction only, namely, from point to tail.

LESSON XV.

FORGING CHISEL.

TAKE a rod of steel $\frac{7}{8}$ inch diameter (if octagonal is not obtainable) and heat to a blood-red, and make octagonal, by using the hand hammer and flatter, for about 6 inches in length. Then draw down the cutting portion, as in Fig. 52, using the flatter on each wide and narrow side alternately; so as to hammer the steel well together at the cutting edge, and to the dimensions

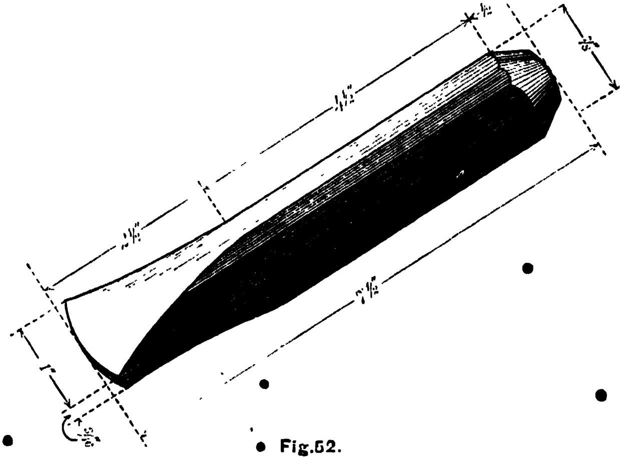


Fig. 52.

shown in Fig. 52. Then cut off the chisel from the bar with a hot chisel, and holding it in a pair of hollow tongs, forge the head portion as shown. Then reverse the chisel in the tongs, and heat the thin end for about 2 inches up, to a blood-red colour; then dip the point vertically into cold water to a depth of about 1 inch, and move about at that level to thoroughly cool the point. Take out and rub the cooled end with a piece of grit-stone until bright, then watch the colour appear, and run down towards the point, until it becomes of a brown yellow colour, when it should be dipped vertically and entirely into cold water, and cooled quickly.

LESSON XVI.

FORGING HAMMER HEAD.

TAKE a piece of 1⅝ inch diameter round steel, and heat in a forge to a dull-red heat, taking care not to exceed this heat, or the steel may be burnt, and become useless.

Take a round taper mandrel, about ⅝ inch mean diameter, and punch a hole through the centre of the steel, and 2¼ inches from the end. Enlarge the hole by punching, and use an oval tapering mandrel until the hole becomes as shown by dotted lines in Figs. 53 and 54.

Then flatten the two sides, while the mandrel is in, parallel with the length of the oval hole; and with a fuller draw down each side of the hole, to form facets, A, B, etc. (Figs. 53 and 54). Knock out the mandrel and forge the ball-pane end; taking care to hammer the steel well up together.

Grasp the ball-pane end in a pair of hollow tongs and heat the portion that will form the face end; and with a "hot" or shaft chisel cut off the head about ¼ inch longer than the dimensions given; and hammer the face end well together, to make the steel more dense. If the head is to be branded, it should be done with the mandrel in place, taking care to hold the brand level. Anneal the head thoroughly by heating it to a blood-red heat, and placing in a box containing sufficient lime to cover the head, and allow it to cool slowly.

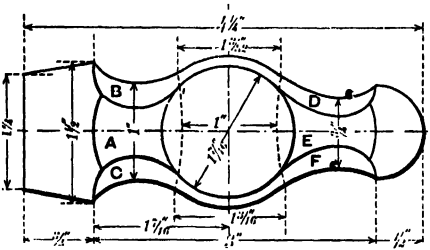


Fig. 53. Elevations.

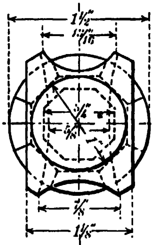


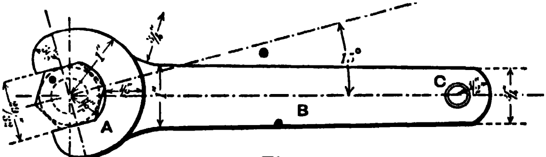
Fig. 54.

LESSON XVII.

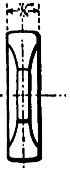
SPANNER.

TAKE a piece of steel 2 by ⅜ inch, and about 2 feet long, jump up the end, A (Fig. 55), to 2¼ inches diam., and ½ inch thick, and draw down the handle portion, B, to the angle shown, allowing a full sixteenth all round for finishing, and anneal carefully. Centre the blank in line with the handle, and turn same to dimensions given in Figs. 55, 56 and 57.

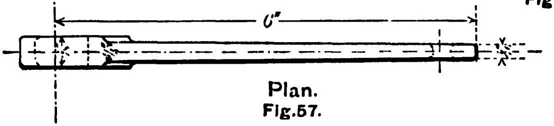
File the sides and jaw end, A, roughly to shape, and line out jaws to angle and shape shown. Drill out jaw with one or more drills, and clear out space between drill holes with a hand-chisel and files. Drill and countersink a ¼-inch clearing hole at C, Figs. 55 and 57. Smooth file all over, and make the jaws carefully parallel one to another, and at right angles to the handle portion, and polish all over. The jaws may be tempered slightly. The jaws are usually two hundredths (·02) wider than the flats of the nuts, and if made to the angle shown will turn nuts in less space than a straight spanner.



Elevation.
Fig. 55.



Elevation
Fig. 56.



Plan.
Fig. 57.

TABLE OF WHITWORTH NUTS. (UNWIN'S "MACHINE DESIGN.")

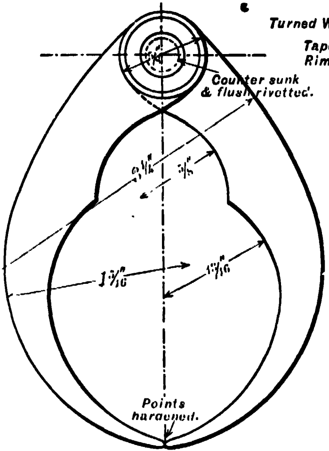
DIAM. OF BOLT. Inch.	WIDTH OVER FLATS. Decimals. Inch.	WIDTH OVER FLATS. Approx. Inch.	HEIGHT OF BOLTHEADS. Decimals. Inch.	HEIGHT OF BOLTHEADS. Approx. Inch.
⅛	·338	21/64	·1093	7/64
3/16	·448	29/64	·1640	5/32
¼	·525	33/64	·2187	7/32
5/16	·601	19/32	·2734	17/64
⅜	·709	45/64	·3281	21/64
½	·919	29/32	·4375	7/16
⅝	1·10	1 3/32	·5468	35/64
¾	1·30	1 19/64	·6562	21/32
⅞	1·47	1 31/64	·7656	49/64
1	1·67	1 43/64	·875	⅞

Thickness of nut = diam. of bolt.

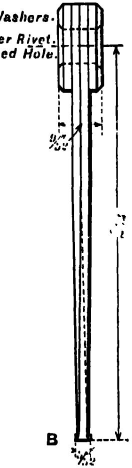
LESSON XVIII.

TO MAKE A PAIR OF OUTSIDE CALLIPERS.

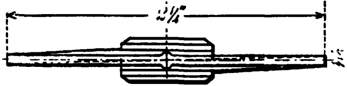
TAKE a piece of sheet steel $4\frac{5}{8}$ by $\frac{7}{8}$ by $\frac{3}{32}$ inch thick, and mark on one side with a brass scriber as shown in Fig. 61.



Elevation.
Fig. 58.



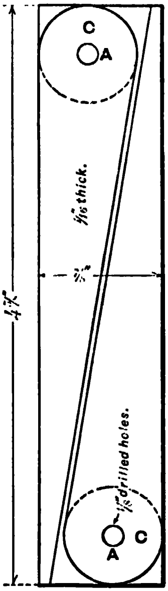
Elevation.
Fig. 59.



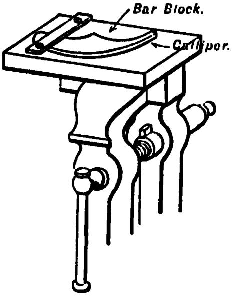
Elevation.
Fig. 60.

Drill two holes at A A $\frac{1}{8}$ inch diameter, and then cut them out to the scribed lines with a hammer and hand-chisel. Flatten and place them with the scribed lines on the outsides and rivet them together by a rivet passing through the drilled holes. File up the edges roughly to the scribed lines, and heat the callipers to a blood-red heat; and bend them over an anvil beak or round bar to shape shown in Fig. 58, and file up the edges to get both alike.

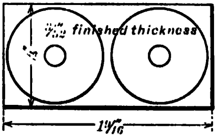
Then cut out the rivet and forge each point a little wider than the thickness of the steel, as at B, Fig. 59.



Elevation.
Fig. 61.



Elevation.
Fig. 62.



Elevation.
Fig. 63.

Take a bar block and fix it in the vice, clamp the callipers down as shown in Fig. 62, and file them on both sides, taking especial care to keep the part C, where the washers come, perfectly flat and parallel. Use a rough file at first, then a smooth one, afterwards chalking the smooth file to prevent "pinning," *i.e.*, small pieces of metal clogging the file teeth, which may be removed by using a file card or brush, a brass scriber, or a piece of flat brass hammered to a thin edge.

When filed smooth all over (leaving the curve of the larger ends and points to be finished later); finish the polishing by using coarse emery-cloth at first and fine afterwards and a little oil.

Take a piece of flat steel, similar to that used before, mark out and drill two $\frac{1}{8}$-inch diameter holes, and cut out to form the washers, as shown in Fig. 63. Drive them on a mandrel, and turn and face each on both sides, keeping them perfectly flat and parallel; and chamfer as shown.

Place the legs together with the washers in their finished position, and with a slightly taper rimer and a little oil, rime out the holes, leaving a gradually tapering hole all through the four thicknesses of metal.

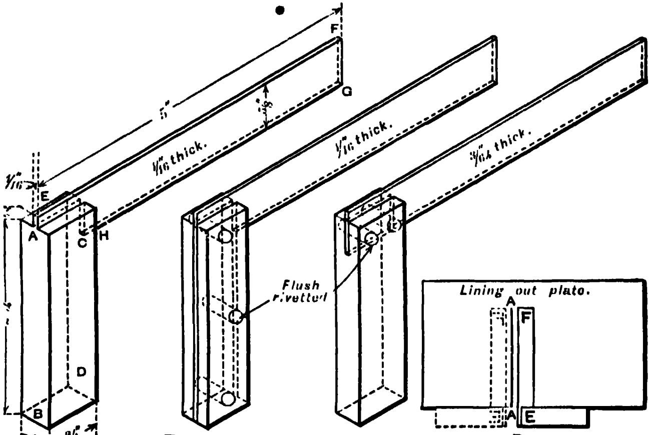
Take a piece of $\frac{1}{4}$ inch diameter steel, anneal centre, and turn taper to form a rivet, fitting the taper hole all through, making it about $\frac{3}{16}$ inch longer than the hole. Take apart, and countersink the washers slightly on the outside, and, after wiping all quite clean, put them together with a little oil upon the wearing surfaces and rivet up gradually, taking care to spread the rivet equally so as to fill the countersink, and so that the callipers will open and close with the pressure of the hand. Ease off the projecting rivet, and file the large ends carefully down to the washers, and polish. With care, so as not to bruise the legs, set each of them with a mallet one half their thickness in opposite directions, as shown in Fig. 60, so as to make the points line with one another when closed. File the points rounding, as shown, and parallel to one another, and polish.

The points are sometimes hardened slightly to prevent wear.

LESSON XIX.

TRY OR BACK SQUARES.

THE square being forged roughly to the shape shown in Fig. 64, and annealed, should be filed with a rough file on the face A B; making it at right angles to the length of the blade. Then E F filed at right angles to A B, and G H and C D made roughly parallel to E F and A B respectively. The sides should then be filed up square with the face, and the blade reduced to an equal thickness all through, and the ends squared.



Elevations.

Fig.64. Fig.65. Fig.66.

Plan.

Fig.67.

When all is roughed out, it should be smooth-filed, and made more accurately square. Then C D and A B are filed and made accurately parallel with one another, also E F and G H, taking care to make them at right angles to A B and C D.

This may be tested by placing the square on a lining-out plate, in the manner shown in Fig. 67, and scribing the line A A upon its surface, then turn the square over into the position shown by the dotted lines, and see if the edge E F exactly coincides with the scribed line A A. If not, the square must be corrected, until the edge E F falls upon the line A A, when placed in either of the two positions. When corrected, the square should be polished. Any stamping or figuring upon the square should be done before it is smooth-filed or finally adjusted.

Another method of making a square is to make the stock and blade of one piece of steel, and to strengthen the thin stock by riveting a piece of steel on each side, with flush countersunk rivets as shown in Fig. 65.

Another method is to make the blade separate from the stock, as shown in Fig. 66, in which case a slot is cut with a saw, in the stock, and the blade fitted in tightly. It is then set square, and two rivet holes drilled through stock and blade while in position, and fitted with two steel rivets, and countersunk riveted over, so as to fill the holes well, and be flush, and not to show when finished.

These squares may be made of various materials, and should be finally adjusted after riveting, in a similar manner to the solid square first described.

Lesson XX.

SURFACING.

The work having been previously prepared by chipping and filing, or other methods, should be smooth-filed until perfectly flat, as tested with the straight-edge. It should be wiped clean, and placed carefully upon a surface-plate, the face of which has been smeared over with a very thin coating of "reddle," a mixture composed of red lead and oil.

By giving the work a slight circular motion while resting upon the surface-plate, the high parts which come in contact with the surface-plate will become reddened, and should be eased off at first by filing with a dead-smooth file, and when more correct, by scraping; taking care to remove only a very small quantity of material at each scrape, until the work shows the surface-plate to touch in very small patches, close together, all over the surface of the work.

Elevations.

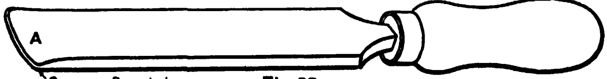


Fig.68.

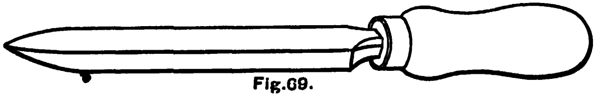


Fig.69.

The work and the surface-plate should be frequently wiped clean, and tried again and again, and the burnished or bright patches scraped, until the work has attained sufficient accuracy.

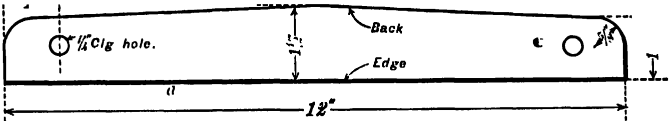
The scrapers generally used are shown in Figs. 68 and 69. Fig. 68 is forged and filed to shape, so as to cut at A only, and hardened and tempered to a straw-yellow colour. Fig. 69 is usually made from a worn triangular file, ground to shape, both being finished upon a hard oil-stone.

LESSON XXI.

STRAIGHT-EDGES.

TAKE three pieces of steel, 12 inches long, 1½ inch wide, and 3/32 inch thick, anneal them, and drill a ¼ inch hole through the ends.

File or grind up the sides, and pass bolts through the holes at the ends, forming the three pieces into one bar, and file or plane up the backs to shape shown in Fig. 70.



Elevation.
Fig. 70.

Accurately plane or file up the edges *a*.

Unbolt and number the bars 1, 2, and 3, and then compare 1 and 2 together, edge to edge, and if they do not exactly coincide, ease No. 2 to fit No. 1. Then compare No. 3 with No. 2; easing No. 2 to fit No. 3.

Then compare No. 3 with No. 1; easing No. 1 to fit No. 3. Then compare No. 1 with No. 2, and so on repeating the alternate comparisons until they all coincide one with another, and form true straight-edges. Use a smooth file until approximately correct, and then a scraper to finish with, "reddling" the test one on the edge to indicate the high places of the edge tested.

It is necessary to have three bars, as two may agree when tried together, and yet be hollow or round; turning end for end is of no use, as if the curvature is equal they will agree.

Always be careful to finish the sides and back, especially of a cast-iron straight-edge, before attempting to finally correct the edge.

LESSON XXII.

TO TURN A HAMMER HEAD.

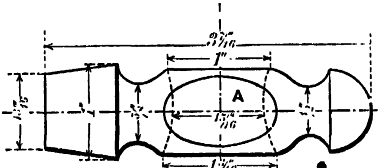
TAKE a piece of steel 1¼ inch diameter, and 3¾ inches long, and anneal it.

Square the ends and centre, as in Lesson VI. or X.

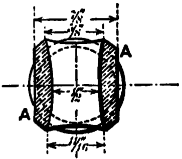
Place a carrier upon one end, and turn to dimensions shown in Figs. 71 and 73.

Then mark out the position for the shaft-hole, and shape of side, with scribe lines, as shown in Figs. 71, 72, and 73, and cut out the hole by drilling.

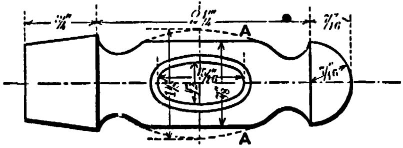
Place the head in a vice, and file or plane away the metal at the sides A A, and clear out the hole by filing; making its section as shown in Figs. 71, 72, and 73, and file off the ends.



Elevation.
Fig.71.



Section.
Fig.72.



Plan.
Fig.73.

Make the circular-face perfectly flat, and the ball-pane rounding, as shown.

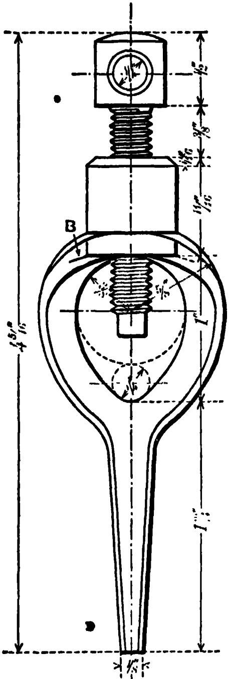
It should be branded carefully, and hardened at both ball-pane and circular-face, to a dark yellow colour.

LESSON XXIII.

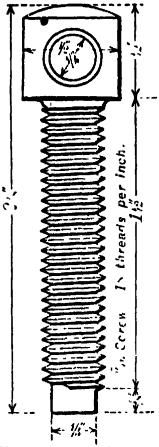
LATHE CARRIER.

TAKE a piece of round iron 1½ inch diameter, and cut off 4 inches long, square ends, centre, drill up, and countersink as in Lesson VI. Turn to shape and dimensions shown in Figs. 74 and 76; line out with scribe lines as shown, and cut the metal A A away by chipping and filing, or planing.

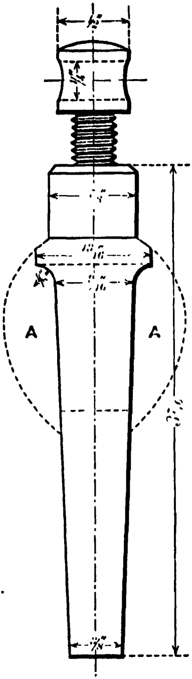
Line out the hole, as shown in Fig. 74, and cut out the metal by drilling holes, as shown; cut through the metal between the drilled holes with a cross-cut chisel from each side, taking care not to bruise the portions previously turned during this operation. Finish the hole by filing to dimensions, and ease away metal at B.



Elevation.
Fig.74.



Elevation of Screw.
Fig.75.



Elevation.
Fig.76.

Drill the hole for the screw with a $\frac{5}{16}$ inch tapping-drill (¼ inch diameter), and tap same with taper, second, and plug taps.

Then smooth-file all over, the turned portions being done in the lathe, and polish.

Take a piece of ½ inch diameter round steel and cut off to 2¼ inches long, square ends, centre and turn to dimensions shown in Fig. 75. Drill a ¼ inch hole through the centre of the head, taking care to keep it at right angles to the axis of the steel, and slightly countersink same. Place a carrier upon the head, and chase the thread as described in Lesson XXVI., or screw it with the stocks and dies as in Lesson XXV., taking care to make it a good working fit and without shake. Ease away the thread at the point as shown, and harden same slightly to prevent its spreading with use.

LESSON XXIV.

PLUMB-BOB.

TAKE a piece of iron 2 inches diameter and about 4 inches long, square the ends, centre, and drill up one end with a ⅜-inch tapping-drill to depth shown in Fig. 78, and tap same.

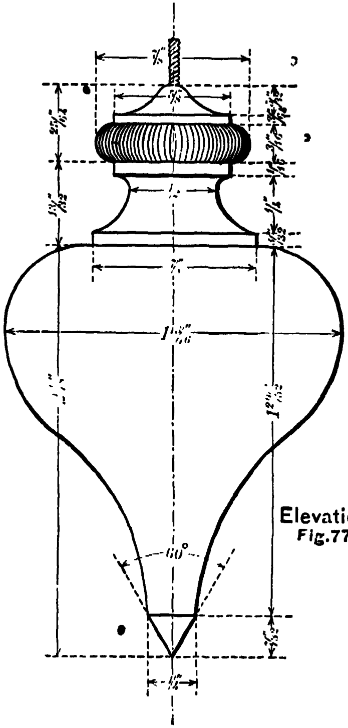
Countersink hole slightly, and turn to shape and dimensions shown in Fig. 77, and polish.

Grasp the ball of the bob in a universal or bell chuck, and turn point to shape, and polish.

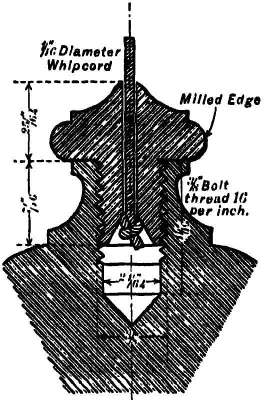
Take a piece of iron 1 inch diameter and 1 inch long, and centre and drill same right through with a inch diameter clearing hole, and countersink as shown in Fig. 78.

Turn the end ⅜ inch diameter, and screw same with a chaser to fit well the tapped hole in the ball.

Screw cap piece into a ⅜ inch screw-chuck, and turn to dimensions shown, milling the top bead as shown, and polish, screwing the cap into the bob.

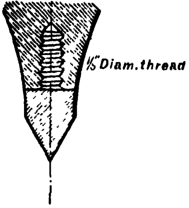


Elevation.
Fig.77.



Section
Fig.78.

Section.
Fig.79.



The plumb-bob may be made entirely of steel, iron, brass, or gun-metal, or a combination of either metals according to taste, and the point, usually made of steel and screwed into bob, as shown in Fig. 79, may be hardened to prevent its being injured.

LESSON XXV.

SCREW-CUTTING WITH STOCKS AND DIES.

FOR making an external thread with the stocks and dies, the blank to be screwed should be turned or filed round to the diameter at the top of the finished thread, to remove all scale or skin that would injure the dies; and be placed in a vice either horizontally or vertically, the latter preferably.

A little oil should be placed upon dies and blank, and the dies opened to drop over the blank for about two-thirds of their depth; taking care to place them square upon the blank. Then screw up the adjusting screw of the dies, so as to force the teeth of the dies slightly into the blank. Then move the stocks round upon the blank, by pressing on the handles horizontally in opposite directions, and with a slight downward pressure, turning the stocks in the direction of the screw to be cut, namely, right or left hand, as far as it is desired to screw the blank.

Then run them back in the reverse direction to the top, oil the dies, and tighten the adjusting screw, and work down as before.

Slack the adjusting screw and run the dies back, taking them off and cleansing the teeth from the cuttings; then oil again and adjust upon the blank, and work up and down until a full thread is obtained, and the screw is of the desired size. Be careful to screw the blank parallel, and tighten the adjusting screw at the top or start of the thread only.

LESSON XXVI.

SCREW-CUTTING WITH HAND TOOLS IN THE LATHE.

TAKE a blank turned to a diameter a little larger than the top of the thread to be cut, and fix a carrier upon the head and adjust between the lathe centres, clamp the hand-rest, the top of which should be smooth and flat, about ⅛ inch away from the work; and to such a height that the top of the chaser may be level with the lathe centre when in use.

Set the lathe in motion, and with a sharp-pointed graver, resting point down on the hand-rest and held as in Lesson VIII. Give the graver a sharp twist, so as to turn upon the blank a turn or so of a spiral—somewhat approximating to the pitch of the screw thread to be chased. Then take a chaser or screw-tool of the required pitch, and oiling the chaser and top of hand-rest, press the chaser down upon the rest and into the spiral cut by the graver, and allow it to travel along, increasing the length of the spiral by short stages, by commencing at the point and allowing it to travel one or two turns farther along at each cut.

When the thread is started truly all along the blank, press the chaser harder into cut, taking cut after cut until a full thread is obtained, being careful to hold the chaser at right angles to the work; and to advance the spiral gradually, and not by fits and starts, in order to avoid "drunken threads."

Sometimes the spiral is started upon the blank by means of the stocks and dies, but after a little practice the above method with the graver is preferable.

Threads upon brass and similar metals are started with the chaser direct, and being upon softer materials can be more easily kept true and uniform.

LESSON XXVII.

SLIDE REST TOOLS.

FIGS. 80 to 94 illustrate a simple set of slide-rest turning tools.

Fig. 80.—A front roughing or point tool, used for roughing out work.

Figs. 81 and 82.—Right and left hand roughing or side tools, for roughing out corners and rough surfacing cuts.

Figs. 83, 84, and 85.—Right and left-hand knife tools, used for squaring collars and ends of shafts, and for finishing surfacing cuts.

Figs. 86 and 87.—Parting tool, used for dividing pieces of metal while revolving in the lathe.

Figs. 88 and 89.—Boring tools. The round one for roughing out holes and recesses, the other for smoothing cuts.

Figs. 90 and 91.—Screwing tool (outside) for R H vee threads; the rake of which is determined by the pitch of the screw to be cut.

Figs. 92 and 93.—Screwing tool (inside) for L H vee threads.

Fig. 94—Diagram of the cutting angles for steel, wrought-iron, cast-iron, and brass.

The above tools should be forged to shape, at a blood-red heat, taking care to hammer the cutting edges well together, to consolidate them as much as possible. They should be annealed, and ground or filed to shape and angles, and hardened and tempered to a straw-yellow colour.

Fig. 80.

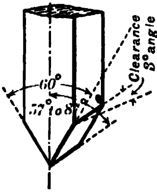


Fig. 81.

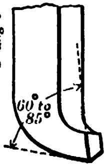


Fig. 82.

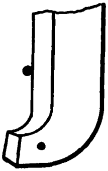


Fig. 83.

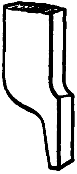


Fig. 84.

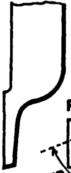


Fig. 85.

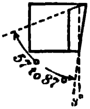


Fig. 86.

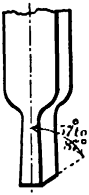


Fig. 87.

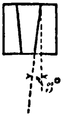


Fig. 88.

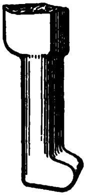


Fig. 89.

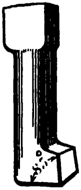


Fig. 90.

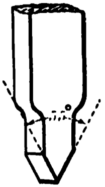


Fig. 91

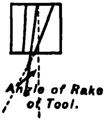


Fig. 92.

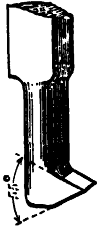


Fig. 93.

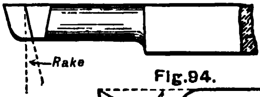
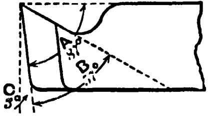


Fig. 94.



A. *Angle for Cast iron and Brass.*
B. *Angle for Wrought iron and Steel.*
C. *Clearance Angle.*

The cutting angle found most useful is 60° for steel and wrought-iron, and 90° for brass and cast-iron. The angle for finishing is usually about 90°; all cutting edges should have a clearance angle of 3°, and should be oilstoned after tempering.

Spring tools are not described, as they fail to produce accurate work. For finishing cuts, a wide parting tool, ground slightly rounding on its edge, and oilstoned to about 85°, used with a light scraping cut, well lubricated, and slow feed, will be found useful.

The point of the tools should be fixed level with the point of the lathe centres, so as to cut tangential to the work.

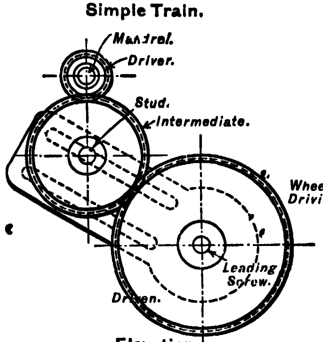
If it is necessary to "pack" the tool to this level, it should be done with parallel strips of metal, so as to retain the correct cutting angle.

The tools described above are those ordinarily used, but small pieces of steel, having cutting edges similar to those described above, are now largely used; and when fixed in rigid holders, are useful and economical.

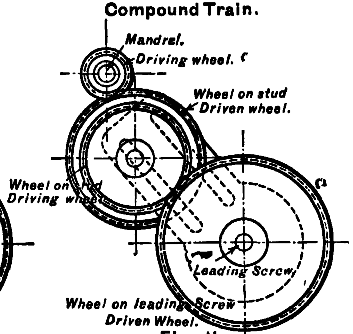
LESSON XXVIII.

CHANGE WHEELS FOR SCREW-CUTTING.

WHITWORTH lathes are usually supplied with change wheels advancing by 5 teeth from 20 teeth to 140, and by 10 from 100 to 140, and one extra wheel of 40 teeth.



Elevation.
Fig. 95.



Elevation.
Fig. 96.

These wheels are used for screw-cutting, and are placed upon the lathe, as in Fig. 95 or 96.

The pitch of a screw is the distance between the centres of the threads in one revolution, and is usually expressed as so many threads (or pitches) per inch.

Rule 1.—For finding change wheels :—

$$\left.\frac{\text{Number of threads per inch in leading screw}}{\text{Number of threads per inch in screw to be cut}}\right\}\text{and add cyphers,}$$

or multiply by any convenient number.

Example.—Required to cut 6 threads per inch ; leading screw 4 threads per inch :—

Threads per inch in leading screw = 4 (numerator)
" " " screw to be cut = 6 (denominator)

$$\text{adding cyphers } \frac{40}{60} = \frac{\text{driving}}{\text{driven}} \text{ wheels required.}$$

$$\text{Or, } \frac{4}{6} \times \frac{5}{5} = \frac{20}{30}; \qquad \text{or, } \frac{4}{6} \times \frac{10}{10} = \frac{40}{60}.$$

To prove whether any train of wheels is correct, the number of teeth in driving wheels multiplied together, and the number of teeth in driven wheels multiplied together, must equal the proportion of the numerator and the denominator.

Rule 2.—For finding the wheels to cut fractional threads :—Reduce the compound fraction to a simple one, and proceed as given above in Rule 1.

Example.—Required to cut 4¾ threads per inch. Leading screw 2 threads per inch :—

$$\frac{2}{4\frac{3}{4}} \cdot \frac{\times 4}{\times 4} = \frac{8}{19} \times \frac{10}{10} = \frac{80}{190} \div \frac{2}{2} = \frac{40}{95} = \frac{\text{driving}}{\text{driven}} \text{ wheels}$$

required for simple train, as in Fig. 95.

Or, $\frac{80}{190} \times \frac{10}{10} = \frac{800}{1900} = \frac{20 \times 40}{20 \times 95} = \frac{\text{driving}}{\text{driven}}$ wheels required for a compound train, as in Fig. 96.

$$\frac{\text{Proving}}{\text{these wheels}} \quad \frac{\times 40}{\times 95} = \frac{40}{95} \div \frac{10}{10} = \frac{4}{9\frac{1}{2}} \div \frac{2}{2} = \frac{2}{4\frac{3}{4}} \, \frac{\text{numerator}}{\text{denominator}}$$

Rule 3.—For finding the wheels to cut screws of decimal pitch.

Write the given decimal as a numerator, and the unit as a denominator, adding as many cyphers as there are figures in the numerator. Multiply the numerator by the number of threads per inch in the leading screw, and the result equals the proportion of the driving wheels to the driven wheels.

Example.—Required to cut ·08 threads per inch. Leading screw, four threads per inch.

$$\frac{\text{Numerator}}{\text{Denominator}} \quad \frac{8 \times 4}{100} = \frac{32}{100} \times \frac{10}{10} = \frac{320}{1,000} \times \frac{10}{10} = \frac{3,200}{10,000}$$

$$= \frac{40 \times 80}{100 \times 100} = \frac{\text{driving}}{\text{driven}} \text{ wheels required.}$$

$$\text{Or, } \frac{20 \times 80}{50 \times 100} \text{ wheels required.}$$

NOTE.—When the number of threads per inch required to be cut can be divided by the number of threads per inch in the leading screw without remainder, the clamping nut under the saddle will drop into gear with the leading screw at any position.

CHANGE WHEELS FOR SCREW-CUTTING.

(MR. ROGERS' RULES.)

RULE 4.—Multiply the number of teeth in the mandrel wheel by the number of threads per inch in the screw to be cut, and divide by the number of threads per inch in the leading screw.

Example.—Required to cut 10 threads per inch, mandrel wheel 20 teeth. Leading screw 4 threads per inch—

Then $\frac{20 \times 10}{4} = \frac{200}{4} = 50 =$ number of teeth in wheel to be placed on the end of the leading screw, and geared with the mandrel wheel of 20 teeth by an intermediate wheel of any number of teeth fixed on the stud. This train of wheels will cut 10 threads per inch.

Example.—Required to cut 8 threads per inch, mandrel wheel 16 teeth, leading screw 4 threads per inch—

Then $\frac{16 \times 8}{4} = \frac{128}{4} = 32 =$ wheel to be placed on leading screw to cut 8 threads per inch.

Example.—Required to cut 10 threads per inch with a compound train (4 wheels). Leading screw 4 per inch.

Then $\frac{4}{10} \times \frac{10}{5} = \frac{40}{50} \times \frac{60}{120} \begin{matrix}\text{driving} \\ \text{driven}\end{matrix}$ wheels required.

Here a fraction, $\frac{10}{5}$, is used to multiply by, of which the numerator is twice the denominator, and the second driving and driven wheels are in the inverse proportion.

LESSON XXIX.

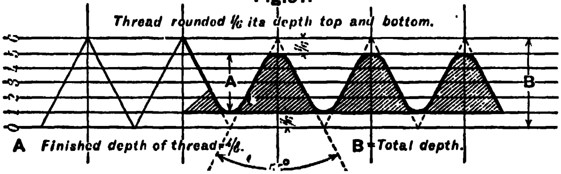
TABLE OF SCREW THREADS.

VEE THREADS FOR BOLTS (WHITWORTH).

DIAM. OF SCREW. Inch.		SIZE OF TAPPING HOLE. Inch.		NO. OF THREADS PER INCH.
$\frac{1}{4}$	...	$\frac{3}{16}$	...	20
$\frac{3}{8}$	...	$\frac{21}{64}$	...	16
$\frac{1}{2}$	...	$\frac{29}{64}$	...	12
$\frac{5}{8}$	...	$\frac{17}{32}$	...	11
$\frac{3}{4}$	...	$\frac{43}{64}$	...	10
$\frac{7}{8}$	...	$\frac{3}{4}$	...	9
1	...	$\frac{7}{8}$	...	8
$1\frac{1}{4}$	...	$1\frac{5}{64}$	...	7
$1\frac{1}{2}$	...	$1\frac{5}{16}$	...	6
$1\frac{3}{4}$	...	$1\frac{17}{32}$	...	5
2	...	$1\frac{3}{4}$	...	$4\frac{1}{2}$

Fig. 97 illustrates the proportions of the Whitworth Vee thread—that generally used in the United Kingdom for screwing bolts and studs.

Fig. 97.


Thread rounded 1/6 its depth top and bottom.
0
1
2
3
4
5
6
1/6
1/6
A
B
A Finished depth of thread = 4/6.
B = Total depth.
55°

Square threads for bolts are usually half the pitch of vee threads, and depth of thread = $\frac{19}{40}$ pitch.

VEE THREADS FOR WROUGHT-IRON PIPES.

SIZE OF BORE.	DIAM. AT TOP OF THREAD.	DIAM. AT BOTTOM OF THREAD.	NO. OF THREADS PER INCH.
Inch.	Inch.	Inch.	
$\frac{1}{8}$	$\frac{13}{32}$	$\frac{23}{64}$	28
$\frac{1}{4}$	$\frac{17}{32}$	$\frac{7}{16}$	19
$\frac{3}{8}$	$\frac{21}{32}$	$\frac{9}{16}$	19
$\frac{1}{2}$	$\frac{13}{16}$	$\frac{23}{32}$	14
$\frac{3}{4}$	$1\frac{1}{32}$	$\frac{29}{32}$	14
1	$1\frac{9}{32}$	$1\frac{5}{32}$	11
$1\frac{1}{4}$	$1\frac{21}{32}$	$1\frac{17}{32}$	11
$1\frac{1}{2}$	$1\frac{7}{8}$	$1\frac{3}{4}$	11
2	$2\frac{11}{32}$	$2\frac{7}{32}$	11

RULE 5.—To find width of screwing tool to cut square threads—Divide one inch by the number of threads per inch in the screw to be cut, and the result divided by two will equal the width of the tool.

Example.—Four threads per inch to be cut—

Then $\frac{1{\cdot}00}{4} = {\cdot}25$ and $\frac{{\cdot}25}{2} = {\cdot}125$ inches width of tool, or one-eighth of an inch.

Example.—Two and a half threads per inch to be cut—

Then $\frac{1{\cdot}00}{2{\cdot}5} = {\cdot}4$ and $\frac{{\cdot}4}{2} = {\cdot}2$ inches width of tool, or two-tenths of an inch.

LESSON XXX.

SCREW-CUTTING WITH SLIDE REST TOOLS.

THE blank to be screwed should be turned slightly larger than the finished diameter at the top of the thread, and the change-wheels to cut the desired pitch placed upon their respective spindles.

Place the screwing tool, which has been previously sharpened to the correct angle in the tool clamp, so that it does not overhang the slide too much and spring; set it square with the aid of the screw-cutting gauge, and clamp it down firmly.

Bring the saddle back against a stop, or the back centre, and set the top slide so that the tool is about ⅛ inch from the end of the work, and towards the back centre. Set the tool in by the cross slide, so that it will just mark the work on the first cut; and set the indicator on the cross slide, or chalk the collars to show how far the tool has been advanced.

Try the clamping nut on the underside of the saddle, to see if it will drop full into gear with the leading screw; if not, pull the lathe round until it does.

Chalk the leading screw and quadrant plate-bracket at the top, and also the centre of the large gear-wheel and head-stock. These chalk marks indicate the relative positions of work and leading screw, when the clamping nut was put into gear.

Commence cutting the screw by oiling or lubricating the work. Start the lathe, and allow the tool to travel nearly to the end of the desired screw; stop the lathe and pull round by hand, until the end of the screw is reached; if a vee thread is being cut, ease the tool out gradually at the end of the thread, while the lathe is moving round.

A practised screw-cutter does not stop the lathe at the end of the screw, but is able to judge the exact moment to simultaneously take the tool out of cut, and clamping nut out of gear.

If a rounded, buttress, or square thread is being cut, a hole the same width as the space between the threads should be drilled at the end of the thread, to a depth equal to the finished depth of the thread, to form a clearance for the tool. If the work is removed from the lathe for this purpose, care must be taken to replace it exactly in its former position, or the tool will not "take up" the cut as before, and will require re-setting, and the chalk marks altering. When the tool has reached the end of the thread, take the clamping nut out of gear, and work the saddle back against the stop, or back centre. Examine the thread on the screw (while in the lathe) to see if the pitch is correct. Then set the tool again into cut, judging by the indicator, or chalked collars, how far to advance it. Then pull the lathe round until the chalk marks on the gear-wheel and headstock, and leading screw and bracket correspond. Then drop the clamping nut into gear, lubricate the work, and proceed to cut the screw as before; repeating until a full thread has been cut.

Vee threads are usually finished by hand, with screw tools or chasers, which round the thread top and bottom to the correct radius; but only very little work should be left for the chaser to do, as it requires great care in their use to keep the work parallel.

Square and similar threads are finished with the slide rest; the screwing tool being carefully oilstoned for the finishing cuts.

If the number of threads per inch of length in the screw to be cut will divide by the number of threads per inch in the leading screw without remainder, the clamping nut will drop into full gear at any time, and the chalking upon the headstock and leading screw can be omitted.

LESSON XXXI.

SCREW-CUTTER'S GAUGE AND ITS USES.

TAKE a piece of steel $2\frac{1}{8}$ inches by $1\frac{3}{4}$ inch, and $\frac{1}{16}$ inch thick, and mark out to shape and dimensions shown at A, Fig. 99. Cut out roughly to shape with a hand chisel, and file to dimensions. Drill a $\frac{1}{8}$ inch hole in the position shown, and file out the angles accurately (a good method is to fit a piece of thin metal accurately to the drawing, and use as a gauge), keeping them perpendicular to the opposite side. The angular points may be cut in with a fine saw, as shown at A′, Fig. 99. This enables the point of the tool tested to fit well into the angle.

Cut out the bevel portion, B, Fig. 99, drill $\frac{1}{8}$ inch hole, and file to shape carefully. Drill, cut out, and turn upon a mandrel the two washers at C, Fig. 98, to dimensions shown. Grasp the washers, bevel and gauge together in a vice, and carefully rime out the hole through the four thicknesses with a slightly taper rimer, and turn and fit a taper steel pin. File the whole smooth, and polish, and flush-rivet together as shown, so that the bevel can be adjusted with moderate pressure, similar to callipers in Lesson XVIII. A good way to connect the bevel with the gauge is to turn a taper pin with a head similar to

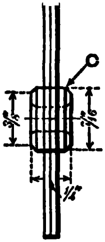


Fig.98.

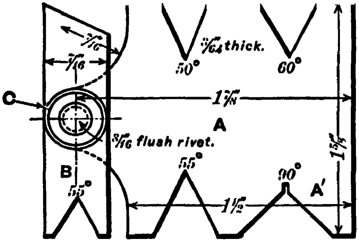


Fig.99.

Fig.100.

Elevations.

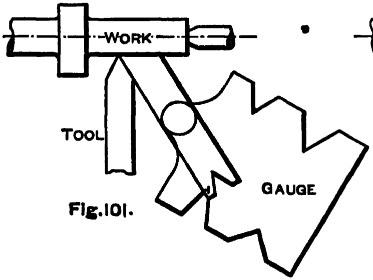


Fig.101.

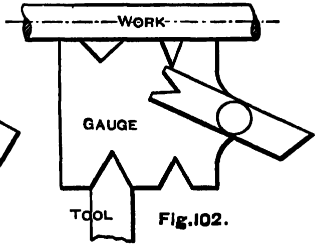


Fig.102.

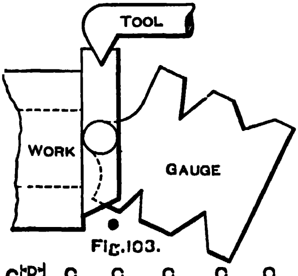


Fig.103.

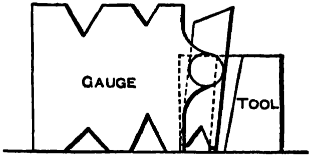


Fig.105.

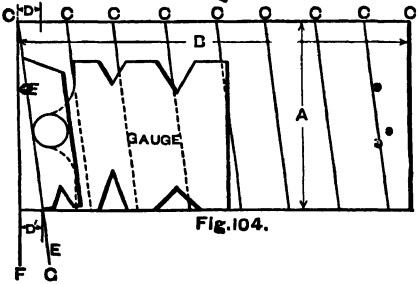


Fig.104.

A — *Diam. at top of thread.*

B — *One inch divided into number of threads per inch in screw to be cut.*

C — *Divisions showing tops of threads.*

D D′ — *C divided into two.*

E — *Line joining* **D** *and* **D′** *giving angle* **F C G** *at which gauge for rake is set.*

one of the washers, and make only one washer, and rivet them together.

Figs. 101, 102, and 103 show how the gauge is used to set the screwing tool square with the work—for cutting inside and outside threads.

Fig. 104 shows how threads are set out to obtain the proper rake of screw tool, and Fig. 105 its application to the tool.

LESSON XXXII.

HARDENING.

STEEL is hardened by heating to a blood-red heat in a clean fire, free from clinker; and plunging into cold water or oil, moving the steel about to cool it equally all over. This is known as hardening steel "right out."

Iron is "case-hardened" by polishing its surface and placing in a covered iron-box filled with small pieces of horn, hoof, bone and leather, and heating the whole to a red heat, when the box should be plunged into cold water and cooled quickly. When the iron is taken out it will be found to have a hard skin or coating formed upon its surface.

Another method of "case-hardening" iron is to heat the polished iron in a very clear fire red hot and immerse it in a box containing sufficient powdered yellow prussiate of potash to cover the surface; and when the iron assumes a dull-red heat, to cool it suddenly in water.

LESSON XXXIII.

TEMPERING.

STEEL lathe-tools are usually tempered by heating the cutting portion to a blood-red heat for about 3 inches up, and then cooling about 1½ inch of the heated cutting portion in cold water, and rubbing the faces of the tool with a piece of grit-stone or emery-cloth until bright. The heat from the uncooled portion will gradually work up to the point, giving the polished surfaces various colours: at first grey, then light yellow, dark yellow, brown yellow, deepening to purple and blue.

The light yellow colour equals a temperature of about 430° Fah., and is the temper used for metal turning-tools, scrapers, and drills; dark yellow, about 470° Fah., for screw-taps and wood-working tools; brown yellow, about 500° Fah., for chipping chisels; and purple, 530°, and blue, 550° Fah., used for springs. The above method is unsatisfactory, as only the point of the tool is of proper temper, and after several grindings the tempering process has to be repeated.

A better way is to harden the tool "right out," by heating to a blood-red heat, and plunging into cold water or oil to cool; then polish the faces of the tool bright with emery-cloth. Heat a wrought-iron collar red hot, and holding the tool to be tempered in a pair of tongs, place it in the centre of the hot collar, turning it round and round to allow of its becoming evenly heated all over. When the desired colour is seen upon the tool, dip it at once in a vessel containing oil or clean cold water; moving it about so as to cool quickly and evenly.

LESSON XXXIV.

SQUARE-CENTREING OR RE-CENTREING WORK THAT HAS ALREADY BEEN TURNED.

CENTRE the ends of the work approximately with a centre-punch or scribing block, and having replaced the back centre with a triangular or square one (one made with 3 or 4 facets forming cutting edges), place the carrier upon one end of the work, and adjust between the centres. Set the lathe in motion and with an L tool, as shown in Fig. 106 (or a flat-ended or vee tool fixed in the slide-rest), and using the hand-rest as a fulcrum, press the approximately centred rod lightly against the triangular centre, lubricating both centre and tool with a little oil, and advance the back centre gradually into the work. The pressure causes the triangular centre to cut away the metal in the centre punched hole, until the work runs true upon the L tool. It should then be drilled up, as in Lesson VI., to prevent the lathe centre from bottoming and destroying its point.

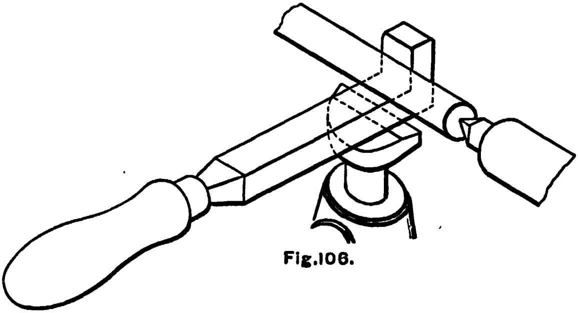


Fig. 106.

LESSON XXXV.

SPIRIT-LEVEL.

TAKE a piece of wrought-iron $6\frac{1}{4}$ inches long by $\frac{7}{8}$ inch square, and square the ends. Mark out position of hole A, and drill same right through $\frac{9}{16}$ inch diameter, as shown in Figs. 111 and 112. Mark out upper face with scribe lines as shown in Fig. 109, and drill holes, D, at ends of slots, counter-sinking same to form bevel.

Drill three holes $\frac{1}{4}$ inch diam. between D D to form slots, and cut out metal between them with a hammer and chisel, saw, or file. Rough-file or plane-up the bottom face parallel with the hole A, and make the top face parallel with the bottom, and the side faces at right angles and parallel one with another, and square with the ends.

File out the slots to dimensions given, making the corners square and sharp, and bevel them at the sides and centre, as shown in Fig. 109.

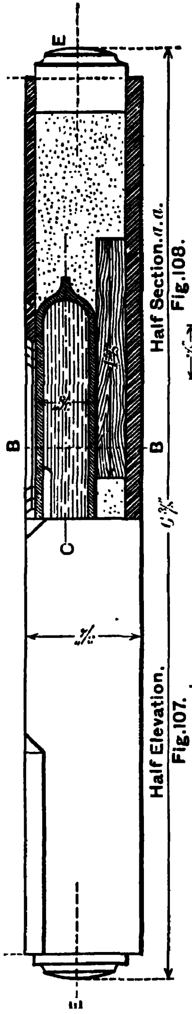
Turn two plugs, E E, to sizes shown, making them slightly taper, so that they may be driven home tightly.

Polish the top, ends, sides, and plugs.

Obtain a glass tube, filled as shown, and fasten to same with glue or gum a piece of coloured silk, unless liquid inside is coloured.

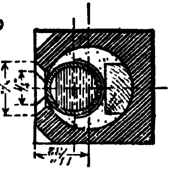
Place the glass in position shown, and wedge it up with hard wood wedges, so that air space in glass is central with the slot, and fill in the remaining spaces with Plaster of Paris rammed lightly in, then put plugs in ends, and allow it to set thoroughly.

Adjust the bottom carefully by filing so that the space in the tube is exactly central with the centre of the slot when placed with the bottom in any horizontal position upon a surface plate.

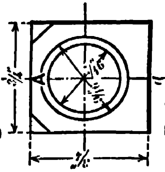


Half Elevation. Fig. 107.

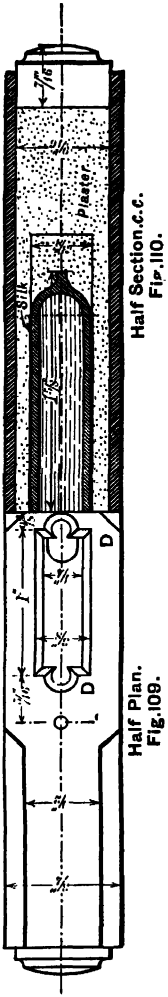
Half Section. a.a. Fig. 108.



Section B B Fig. 112.



End Elevation. Fig. 111.



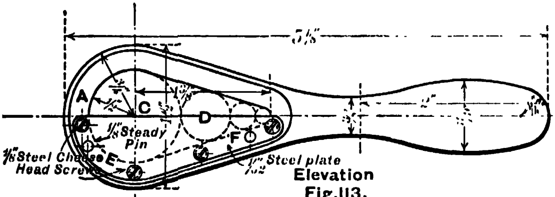
Half Plan. Fig. 109.

Half Section. c.c. Fig. 110.

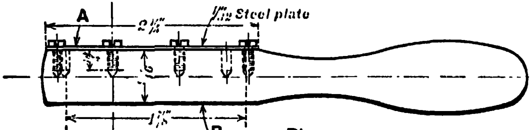
LESSON XXXVI.

CENTREING SQUARE.

TAKE a piece of steel 1¼ inch diameter, and about 6 inches long, and draw down to ⅞ inch diameter at one end, and flatten the other to ¾ inch thick, and 1¾ inch wide. Anneal, centre, and turn to dimensions shown in Figs. 113 and 114, and line out the flat faces, A and B, at equal distances, and parallel with the centre line, and plane or file to the thickness given.



Elevation
Fig. 113.



Plan
Fig. 114.

Scribe a line across the centre of the flat faces A and B, and line out hole C; drill out same with various-sized drills, as shown by the dotted lines, Figs. 113 and 114, and cut out the metal between the holes with a hammer and chisel, or saw, and finish same by filing; making the hole accurately at right angles to the flat faces, A and B.

Take a piece of steel $\frac{3}{16}$ inch thick, anneal, cut to shape, file to sizes given, and polish.

Drill four ⅛ inch clearing holes in the positions shown in Fig. 113, and ease the burr off with a file, and place in position over hole C; taking care that the edge D of the steel coincides accurately with the scribed centre line on A and B, clamp them together in this position, and with a steel scriber, scribe the holes to be drilled in the face A of the stock. Unclamp the steel plate and drill stock with a ⅛ inch tapping drill to depth shown, and tap same to fit well four ⅛ inch cheese-head screws.

Adjust the edge D of the steel plate accurately to the scribed centre line of the hole C, and tighten the four screws.

Drill two ⅛ inch holes in the position E and F, through the steel plate and into the stock, and drive tightly into same two well-fitting steady pins, filing their ends off flush with the upper side of the steel plate.

The stock may be made of iron, brass, or gun metal, according to taste; but the plate should be of steel, slightly tempered.

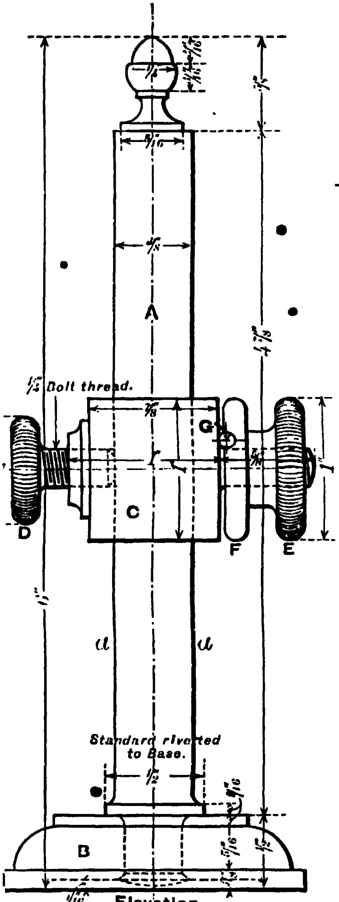
LESSON XXXVII.

SCRIBING BLOCK.

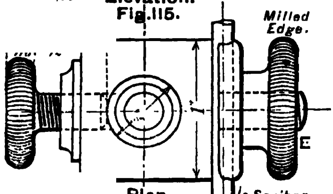
TAKE a piece of steel ½ inch diameter and 6⅛ inches long, anneal, centre and turn to dimensions to form standard at A, Fig. 115, and polish.

Take a piece of steel 2¼ inches by ⅝ inch thick, centre, drill, counter-sink, and turn upon a mandrel to the dimensions shown at B, Figs. 115 and 117, to form base.

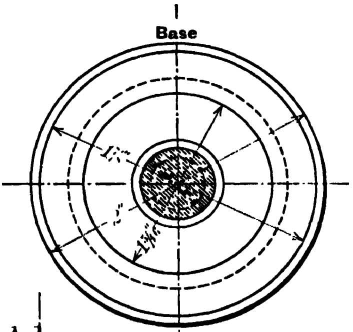
Make the slide C from a piece of steel 1⅛ inch by



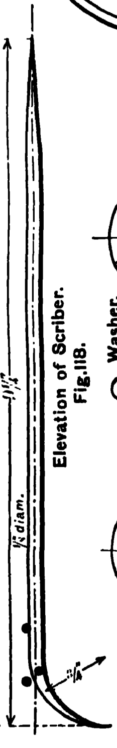
Elevation.
Fig.115.



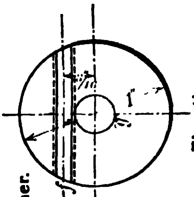
Plan.
Fig.116.



Plan.a.a.
Fig.117.

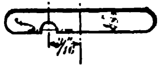


Elevation of Scriber.
Fig.118.

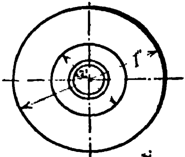


Elevation.
Fig.122.

Washer.
F

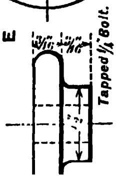


Elevation.
Fig.121.



Elevation.
Fig.120.

Nut.
E



Plan.
Fig.119.

1 inch by 2 inches long, centre, turn, screw, and drill to dimensions shown in Figs. 115 and 116, and tap for ¼ inch adjusting-screw D, and drill a ⅜ inch clearing hole to pass over the standard A, a good sliding fit.

Turn and screw the adjusting-screw D to the dimensions given, and mill its head.

Turn, drill, tap, and mill the nut E to dimensions shown in Figs. 119 and 120.

Drill the piece for the washer F, at *f*, so that the scriber will just push through a good fit; and drill the hole at G to clear the screw on the slide C.

Turn the washer down to the thickness shown in Figs. 121 and 122, and polish all when finished.

Take a piece of ⅛ inch diameter steel wire, and point both ends by filing and grinding. Bend one end as shown in Fig. 118, and harden the points to a brown-yellow colour. Rivet the standard into the base B, and put the whole together.

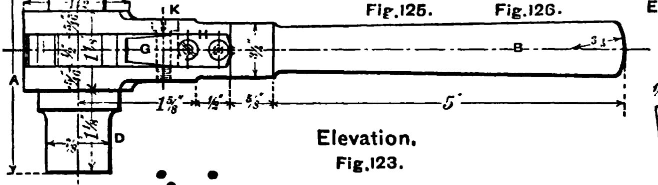
The scriber being placed above the screw at G, enables it to be adjusted to any position on the standard by the screw D.

LESSON XXXVIII.

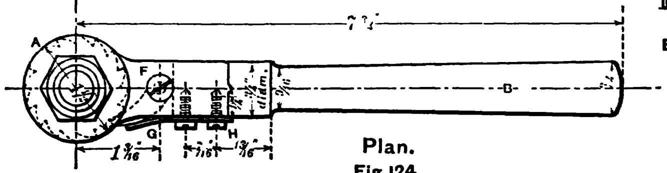
RATCHET BRACE.

TAKE a piece of iron 1¼ inch square and 8 inches long, and heat one end red hot; jump it up to 1¾ inch diameter, and 1⅜ inch thick, to form jaw at A, Figs. 123 and 124.

Draw down the other end to ⅞ inch diameter to form handle B. Square the ends, centre and drill up, and turn to dimensions shown in Figs. 123 and 124, and polish.

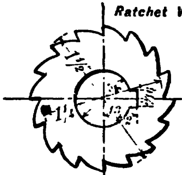


Elevation. Fig.123.

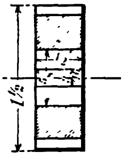


Plan. Fig.124.

Ratchet Wheel.



Elevation. Fig.125.



Section. Fig.126.

Fig.127.

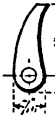
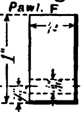


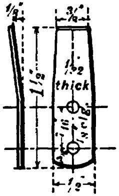
Fig.128.

Pawl. F



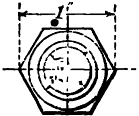
Elevations.

Spring. G



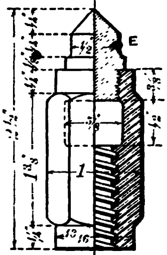
Elevations. Fig.129. & 130.

Fig.131.

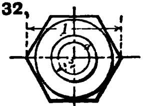


Plan.

Nut. C



Sectional Elevation. Fig.132,



Plan. Fig.133.

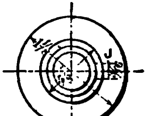
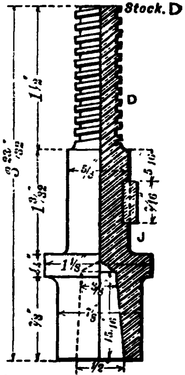
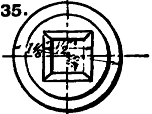


Fig.134. Plan.

Stock. D



Sectional Elevation. Fig.135.



Plan. Fig.136.

Line out the end A as shown, and chip and file to dimensions.

Line out hole and jaw for ratchet-wheel, and cut out metal of same with drills and files, cutters or planing machine, to dimensions shown in Figs. 123 and 124.

Take a piece of iron 1⅛ inch diameter, and 2¼ inches long, square the ends, centre, and drill from each end right through with ½ inch tapping drill for square thread.

Turn the outside to dimensions shown, to form the nut C, Figs. 131, 132, and 133, and line out hexagon. File the hexagon down to the scribed lines. Chuck the hexagon to run true in a universal or bell chuck, and chamber the hole with a boring tool as shown in section, Fig. 132.

Place the hexagon in a vice, and tap the two ends of the hole; one with ½ inch vee thread bolt taps, and the other with ½ inch square thread taps, using taper, second, and plug taps in succession.

Take care not to break the square thread tap in the hole, nor screw the vee thread hole with it, and tap the holes with parallel threads, not smaller at the bottom ends.

Take a piece of iron 1¼ inch diameter, 4 inches long, square the ends, centre, drill up and counter-sink, and drill the end of D, Fig. 135, with a ⅜ inch diameter drill, to a depth of 1⅛ inch. Turn to dimensions and square out hole as shown, with cross-cut or diamond point chisels and files, or a drift, and polish. Screw the other end in the lathe, as in Lesson XXX. to fit the square threaded hole previously tapped in C, Fig. 132, without end or side shake.

Fit and recess into D at J, a steel feather 3/16 inch square and 7/16 inch long; drilling the recess with a flat-bottomed drill, and cutting the metal out between the holes with a small cross-cut chisel and files.

Fit the feather to drive tightly into the recess. Slightly groove the sides of the feather, and when it is driven home, dress the metal at the sides of the recess into the groove, with a sett chisel to hold it in position.

Take a piece of steel ¾ inch diameter, and 1¼ inch long, anneal, square ends, centre, and turn to dimensions shown at E, Fig. 132, to form centre point; and screw end of same, to fit tightly the ½ inch vee threaded hole previously tapped in C, Fig. 132, and polish. Harden and temper the centre point to a dark yellow colour.

Take a piece of steel 1⅝ inch diameter, ⅝ inch thick, centre, drill, and drive same on a mandrel, turn to 1½ inch diameter, and face sides so that it will just push into the jaw at A without side shake. Line out the circumference into sixteen equal spaces, and scribe horizontal lines, to form the tops of the teeth of the ratchet wheel, and cut out same to shapes and dimensions shown at Figs. 125 and 126. File a feather-way through same $\frac{3}{16}$ inch wide and $\frac{3}{32}$ inch deep, and harden and temper wheel to a brown-yellow colour.

Make a steel pawl to dimensions shown at F, Figs. 127 and 128, and drill a $\frac{3}{16}$ inch hole through same to fit pin upon which it will work, and harden and temper pawl to a brown-yellow colour.

Make steel spring G, and drill same in positions and to dimensions shown at G, Figs. 129 and 130, and after polishing, harden and temper same to a purple colour.

Turn a $\frac{3}{16}$ inch diameter, steel pin and screw to dimensions shown at K, Fig. 123, and polish, harden, and temper same to a brown-yellow colour.

Drill holes in stock A B at F, G, H, and K, and tap same to dimensions shown, and to fit their respective screws well, recessing the hole at K with a pin drill to let the head in flush with the surface.

Fit the feather in D to feather-way in ratchet-wheel, so that it will drive in tightly, and place a centre-punch mark at K central with the feather to indicate its position.

File a groove ¼ inch wide and ⅛ inch deep in the lower jaw A, Fig. 123, central with handle B, to admit of the feather in stock D passing through it easily.

See that all is finished and polished, and put same together, the ratchet-wheel into the jaw first, taking care that the feather-way is opposite the slot in jaw A. Then place D in position, entering the feather into the feather-way in ratchet-wheel and driving it home tight with a mallet, so that ratchet-wheel revolves freely in the jaw, and screw on the nut C. Place the catch or pawl in position and fasten with screw, and adjust spring carefully with the two cheese-head screws.

LESSON XXXIX.

SOLDERING.

SOLDERING is a method of uniting metals together by means of alloys which are melted or fused at a lower temperature than the melting-points of the metals to be joined.

Soft solders are those fusible at or lower than 500° Fah., and can be used with mouth blowpipe, plumber's iron, soldering iron, or copper bit.

Ordinary tinman's solder is composed of 3 parts of lead and 2 parts of tin, and melts at about 340° Fah. When solder is composed of 4 of lead, 4 of tin, and 1 of bismuth, it melts at about 320° Fah.; and when of 1 of lead, 1 of tin, and 2 of bismuth, at 202° Fah., or below the temperature of boiling water, which is 212° Fah.

When 3 parts of mercury are added to the last mentioned solder it will melt at about 122° Fah.

Fluxes are substances used for preventing the formation of oxide upon the surfaces to be joined, and to assist the solder to flow freely when melted. Some fluxes also assist to clean the joint.

The fluxes principally used in soft soldering are powdered resin, resin and oil, Gallipoli oil, and killed spirits or chloride of zinc. The latter is made by dissolving strips of sheet zinc in hydrochloric or muriatic acid or spirits of salts, in an open vessel, adding as much strip zinc as the acid will dissolve. An equal quantity of water is sometimes added after the killing.

Killed spirit is especially useful for soldering tinplate repairs, as it assists in cleaning the edges to be joined. It is, however, liable to cause rust, and the joint should be wiped with a damp rag and cleaned with whiting after its use.

Resin is also used, but resin and oil are better, and should be used for new tinplate work, as the joint is not liable to rust, and the oil helps the solder to run cleaner, and the joint can be wiped quite clean with a rag while hot, but with resin used alone, the superfluous flux has to be scraped off.

With these fluxes the edges to be joined require to be much cleaner than when killed spirits are used.

Gallipoli oil is used with bismuth solder for soldering pewter. When soldering zinc, pure acid or spirit is used, as it becomes killed upon application to the joint, which it also cleanses.

In the process of soldering, the edges to be united are first thoroughly cleansed from all foreign matter, then fluxed and placed together in the required position. A stick of solder previously dipped in the flux is taken in the left hand, and a copper bit heated so as to melt the solder readily (but not hot enough to burn the tinning upon its point) in the right hand. The end of the solder should be rubbed upon the point of the bit, which should be moved along the joint to lead the solder into it, adding more solder and flux as required.

Use as little solder as possible, only sufficient to fill the joint, and clean the point of the bit upon a greasy rag before applying it to the joint.

A better joint will be made if the edges can be heated just before or while the soldering is proceeding.

Small articles are best soldered upon a piece of charcoal with the mouth blowpipe.

Bearing "brasses" that are sweated (namely, soft soldered) together for the purpose of turning or boring, and other brass articles, should be tinned before soldering.

A copper bit can be tinned by filing its point clean while hot, and rubbing it upon a block of sal-ammoniac, and rubbing the solder upon it.

After a time the hot copper bit burns a cavity in the sal-ammoniac, which is used as a receptacle for the solder, and a second cavity is also made in the block and used for cleaning the bit.

Tinning a bit with the aid of sal-ammoniac does not cool the point so much as when killed spirits are used.

HARD SOLDERING OR BRAZING.

Hard soldering, or brazing, is a method adopted for uniting metals in a stronger manner than can be accomplished by soft soldering.

Hard solders are those fusible above 500° Fah., and require a blast blowpipe, or forge, to melt them, and are chiefly used to unite copper, brass, bronze, iron, and steel together.

Spelter solder, as ordinarily used, is composed of 1 part of copper to 1 of zinc, and is useful for uniting ordinary sheet brass together.

Some sheet-brass joints require a silver solder, and one composed of 5 parts silver, 5 brass, and 3 of zinc will be found useful. Other compositions are 1½ of copper to 1 of zinc, and 2 of copper to 1 of zinc, which are less fusible, and are useful for soldering copper and cast brass.

For soldering iron, good brass wire is useful.

Silver solder composed of 1 of copper to 2 of silver is used for uniting copper and iron, and makes a neat strong joint, and one which will resist a moderate heat well.

Another composition is 1 of copper, 1 of brass, and 19 of silver; used for brazing steel.

The solder should be kept in a closed box, as the air has a deteriorating effect upon it, to counteract which the solder is mixed with powdered borax, in which form it may be easily applied to the joint.

The flux principally used for hard soldering is borax, which combines readily with most of the oxides, and assists in cleaning the joint. It is usually powdered or ground up with water upon a piece of slate, to the consistency of cream, and is often mixed with pieces of the solder.

In the process of hard soldering, the edges to be united are first well fitted together, and thoroughly cleansed, then fluxed with borax and small pieces of the solder, and bound together with binding wire, or held by other means in the desired position. The joint is then placed in a clear fire, preferably of coke or charcoal, and heated gradually by means of a hot blast, when practicable, applied on both sides of it. The flux will melt first, and run along the clean surface of the joint, and when the joint becomes red hot the solder will begin to fuse, and run into the joint, when more flux and solder should be added; when it has melted and run into the joint, it should be removed at once from the fire and allowed to cool.

Be careful to fit the joint well together before soldering, as hard solders run very "thin," and will not fill up gaps; be careful also to heat the joint only enough to melt the solder, and not to burn and destroy it.

Grooves or channels are sometimes filed from the outside to the inside of a joint, to assist the flux and solder to run in.

Solder containing zinc is useful for joints which cannot be seen; as when fusing, it burns with a blue flame, indicating to the workman that the solder has melted, and that the joint should be at once removed from the fire.

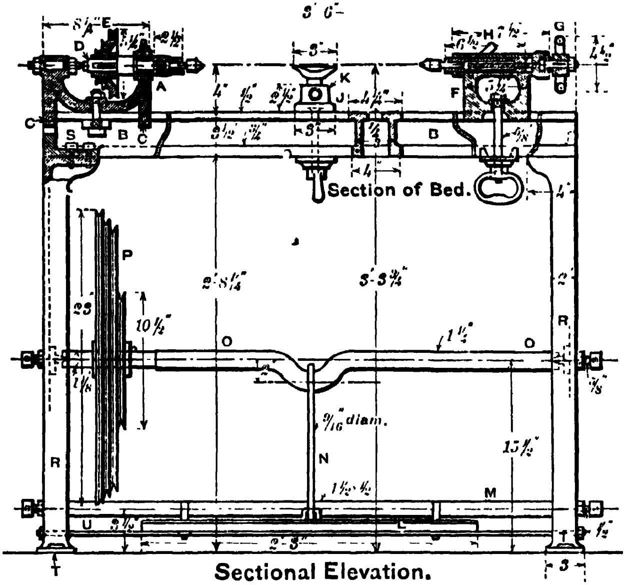
LESSON XL.

FOOT LATHE.

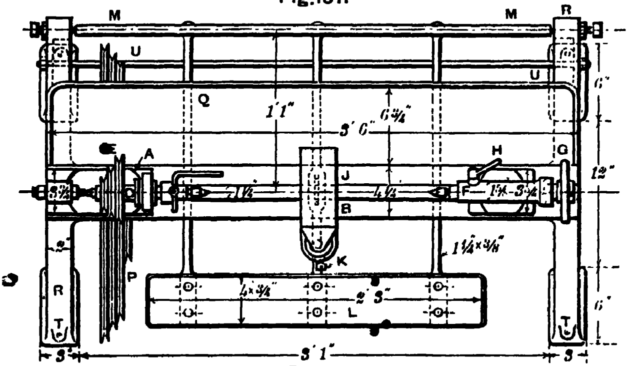
FIGURES 137 and 138 illustrate a small foot lathe, as made by students in the Polytechnic Engineering Workshops.

The whole of the pattern-making, forging, planing, screwing, turning, and fitting was executed in the Polytechnic Workshops.

The headstock A is bolted to the bed B with a square-



Sectional Elevation.
Fig.137.



Plan.
Fig.138.

necked bolt, and adjusted by the screws C between the bed. The mandrel D of steel works in a tempered steel bush, and is screwed at the front end with a $\frac{3}{4}$ inch Whitworth vee thread to take chucks, etc., and is adjusted by a steel cone screw and double nuts at the back. The speed cone E is grooved for three speeds, and keyed to mandrel with a sunk steel feather. The poppet head F is clamped to the bed by a square-necked bolt, washer plate, and hand nut; and adjusted by a left-hand square-threaded screw, keyed to the hand-wheel G, and finally wedged in position by the handle H.

The hand-rest J is clamped to the bed by a T-headed bolt, washer-plate, and hand nut; and the tee rest adjusted for height by the steel screw K.

The lathe is actuated by the treadle board L, bolted to the levers of the rocking shaft M, which is pivoted on steel centres, adjusted by check nuts; and driving a steel hook N, connected to the rocking frame by a taper steel pin for adjustment, and working on to a cranked shaft O, which turns upon steel centres, adjusted by check nuts, and to which a four-grooved balanced speed pulley, P, is keyed with a saddle key, for adjustment upon the cranked shaft, to drive the mandrel at a high speed for turning wood or brass. The lathe is fitted with a stained deal tool board, Q, supported on brackets bolted to standard R, which are bolted to the bed with two screws, S, at each end, and to the floor by coach screws or bolts passing through the holes T. A stay rod, U, is fitted between the standards to increase their stiffness.

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